

Marquette University

e-Publications@Marquette

---

College of Nursing Faculty Research and  
Publications

Nursing, College of

---

9-2018

## Aligning Evidence-Based Practice With Translational Research: Opportunities for Clinical Practice Research

Marianne E. Weiss

Kathleen L. Bobay

Meg Johantgen

Maria Shirey

Follow this and additional works at: [https://epublications.marquette.edu/nursing\\_fac](https://epublications.marquette.edu/nursing_fac)



Part of the [Nursing Commons](#)

---

Marquette University

**e-Publications@Marquette**

***Nursing Faculty Research and Publications/College of Nursing***

***This paper is NOT THE PUBLISHED VERSION; but the author's final, peer-reviewed manuscript.*** The published version may be accessed by following the link in the citation below.

*JONA: The Journal of Nursing Administration*, Vol. 48, No. 9 (September 2018): 425-431. [DOI](#). This article is © Wolters Kluwer Health, Inc. and permission has been granted for this version to appear in [e-Publications@Marquette](#). Wolters Kluwer Health, Inc. does not grant permission for this article to be further copied/distributed or hosted elsewhere without the express permission from Wolters Kluwer Health, Inc.

# Aligning Evidence-Based Practice With Translational Research: Opportunities for Clinical Practice Research

Marianne E. Weiss

Marquette University, College of Nursing, Milwaukee, Wisconsin

Kathleen L. Bobay

Marcella Niehoff School of Nursing, Loyola University, Chicago, Illinois

Meg Johantgen

University of Maryland School of Nursing, Baltimore, Maryland

Maria R. Shirey

University of Alabama Birmingham, School of Nursing, Birmingham, Alabama

## Abstract

Magnet(R) and other organizations investing resources in evidence-based practice (EBP) are ideal laboratories for translational nursing research. Translational research, the study of implementation of evidence into practice, provides a unique opportunity to leverage local EBP work for maximum impact. Aligning EBP projects with rigorous translational research can efficiently meet both EBP and research requirements for Magnet

designation or redesignation, inform clinical practice, and place organizations at the leading edge of practice-based knowledge development for the nursing discipline.

Translational research leverages the significant investment nursing organizations make in evidence-based practice (EBP) education, development, and implementation. In applied healthcare disciplines such as nursing, the goal of research is to discover new or more effective strategies for practitioners to improve patient outcomes. Translational research aligns well with existing EBP efforts and offers a productive approach to achieve this goal. It is recognized that the time from discovery in research to implementation of findings in clinical practice is prolonged [1](#) and often never progresses beyond dissemination in professional journals. Spurred by funding of Clinical and Translational Science Awards,[2](#) models for translational research have emerged to describe stages of progression of research from discovery to delivery in practice [3](#) ([Figure 1](#)). To accelerate the translation of scientific discoveries from nursing research into widespread use in practice, nursing organizations must commit to aligning the substantial effort being invested in development of best practice protocols with translational nursing research that studies the processes and outcomes of implementation of these best practices.

The purpose of this article is to describe a model and methods for hospitals and health systems to use in expanding their nursing research activities. By aligning EBP projects with translational research in a planned, sequential approach, research knowledge will be more effectively and efficiently incorporated into the practice setting, while building the evidence base for successful implementation of research in practice.

## Making the Case for Translational Research

Active engagement in EBP is an expectation in quality nursing organizations. Magnet(R) designation and redesignation standards create the expectation that these organizations will be actively engaged in EBP and research. In the journey toward designation and through redesignation cycles, EBP and nursing research become part of the organization's culture of nursing excellence.[4](#) The value of this culture of nursing excellence is evident in better staffing, work environments, nursing care quality, patient outcomes, and costs of care.[5,6](#)

Magnet organizations and hospitals with active nursing research programs are well positioned to be the prime laboratories for translational nursing research. In a practice discipline, moving evidence to practice and testing new innovations are critical to progress. Testing innovations within practice can speed the uptake of knowledge and foster innovation emerging from real-world clinical problems. The role of nursing research within Magnet organizations was evident in a study of hospital-based nursing research requirements and outcomes.[7](#) Nearly all (98%) of Magnet hospitals, but only 50% of non-Magnet hospitals, reported conducting nursing research studies.

EBP and research are not always distinct activities, and nurses and nurse leaders often coalesce both, leading to lack of differentiation of the nature and purpose of each.[8](#) Evaluation of practice changes associated with implementation of EBP guidelines is sometimes presented as evidence of research activity, blurring the lines among EBP, quality improvement, and research. Part of the failure to distinguish the distinct purposes and methods of EBP and research is the organizational structure for supporting EBP and research. Forty-three percent of hospitals responding to a recent survey of Magnet-recognized organizations indicated they had combined nursing research and EBP councils. In approximately two-thirds of these hospitals, research councils were led by bachelor's degree-prepared or master's degree-prepared nurses.[9](#) Current nursing curricula now emphasize EBP rather than research methods at the master's degree level.[10](#) Doctor of nursing practice (DNP) curricula include preparation in translation of research into practice and integration of new knowledge, with an emphasis on application and evaluation.[11](#) As more DNP-prepared nurses assume EBP/research leadership roles, their training in translation process and evaluation will enhance EBP and research council work. However, lack of research mentorship has been identified as a key factor hindering research

productivity.<sup>12</sup> Partnerships with PhD nurse scientists in academic and practice settings are needed to support rigorous translational research.<sup>13</sup>

Single hospital research projects designed and conducted by individual or groups of clinical nurses to address local clinical problems are often of limited scope, use small sample sizes, and lack scientific rigor. While these small research studies have value for generating local knowledge, developing group consensus on research culture, and providing research training, they are constrained by challenges to recruit adequate sample sizes to detect statistically significant differences. Our thesis is that if conducted using a translational research approach with appropriate attention and support from research design through dissemination, locally based studies have substantial value both for the individual hospital and for the broader research and healthcare communities. These studies provide research evidence in context with results pointing to not only the effect of the EBP or new innovations on patient outcomes, but also a window to understanding how the care environment context and implementation processes themselves can influence care process changes and related patient outcomes. These are the goals of translational research. Building translational research capacity should be a strategic initiative for Magnet organizations and those striving for Magnet recognition.

## The Distinction Between EBP and Translational Research

The definition of EBP has evolved from an explanation of evidence-based medicine as the "conscientious, explicit, and judicious use of current best evidence in making decisions about the care of individual patients[horizontal ellipsis] integrating individual clinical expertise with the best available external clinical evidence from systematic research."<sup>14</sup>(p71) Recent definitions include expansion of relevant evidence sources to include practice-based knowledge within an organizational or local context, local data, patient preferences, and organizational values.<sup>15</sup>

The focus of EBP is the systematic process of review, critique, and synthesis of research evidence and relevant sources of nonresearch evidence to develop a best practice protocol incorporating logistical considerations for implementation in the local context. Some EBP models have extended the EBP process to include evaluation of implementation. This evaluation may focus on protocol adherence, a measure of provider performance, and/or patient outcomes before and after implementation. Although not conducted with the rigor of research, the findings summarize the processes and initial outcomes of the practice change.

In translational science, the clinical implementation stage of translation involves adoption of interventions that have demonstrated efficacy in a research environment into routine clinical care.<sup>2</sup> A hallmark of translational research is testing EBP guidelines, policies, and best practice protocols for their effectiveness within real-time clinical practice. Translational research designs use research methodologies that compare new EBP/best practice protocols or innovations to care protocols in current use. Concurrently, these designs should also incorporate variables that influence the adoption of the new EBP or innovation by individual practitioners and provider organizations and ultimately the ability of the new EBP to improve clinical and operational decision making.<sup>16</sup> Translational methods recognize that new EBPs can produce their intended outcomes only if implemented appropriately, completely, and sustainably.

## Methods Used in Translational Research

Translational research incorporates 2 integrated methods to answer the following questions:

- \* Are efficacious (evidence-based) practices effective in a selected practice environment?
- \* What factors contribute to successful implementation of EBPs and to patient outcomes?

The 2 research approaches used together are 1) comparative effectiveness analysis of patient outcomes and 2) implementation science. In comparative effectiveness research, the goal is to compare the effectiveness of the new protocol (which has evidence supporting efficacy from prior research) to an alternate protocol, often the protocol currently used in practice settings. Following determination of the best practices protocol developed by the EBP team, the research team, under the guidance of a PhD-prepared nurse researcher, can

construct a research design to compare patient outcomes for patients cared for under the new versus the prior best practices protocol. The design for the comparison should include an intervention and control group and may use concurrent or sequential, randomized or nonrandomized sampling, recognizing the limitations of the design and sampling selected. Attention to research rigor in design of the implementation of the best practices protocols and attention to the equivalence of the control group will produce more informative results than less rigorous evaluation approaches typical of EBP projects.

Implementation science is the study of methods, interventions and variables associated with the context of the organization, the behavior of healthcare professionals, and other stakeholder factors that influence the sustainable adoption of EBPs.<sup>17</sup> The focus of implementation science is on the factors that influence the effective implementation of the innovation or evidence such as the organizational and unit cultures, competing demands, training, implementation processes, protocol fidelity, and sustainability of the new practice.

Incorporating implementation science rigor into translational research provides a framework for formative (during implementation) and summative evaluation (end of implementation). The learning that occurs during the process of implementing EBP or innovative practices within local settings is valuable information to feed back into local process improvements and to inform others about implementation strategies for successful adaptation of evidence-based guidelines for use in practice settings. The learning that occurs after the process should inform future modifications.

In developing the implementation plan, assessment of the current practice environment will identify factors associated with the current practice gap, unit culture variables, and facilitators and barriers to adoption of the new practice(s). During implementation, assessment of the accuracy and completeness of adherence to the new protocol, taking the "temperature" of the unit culture, and identifying facilitators and barriers to implementation are formative evaluation methods that allow for incremental redesign of the implementation logistics. These proactive strategies within the implementation process will ensure success of implementation and achievement of intended outcomes. Data collected about the implementation process are then useful in summative interpretation of the research findings.<sup>18,19</sup> Useful guiding frameworks for implementation research include Promoting Action on Research Implementation in Health Services <sup>20</sup> and the Consolidated Framework for Implementation Research.<sup>21</sup>

## Aligning EBP-Translational Research Continuum

Many hospitals have deeply embraced EBP. The reports of these projects tend to include detailed processes for review and selection of an EBP or a set of EBPs for implementation. The processes of implementation are often truncated to the education of nurses in performance of the protocol and rarely describe the many other implementation logistical barriers and facilitators. Process outcomes are reported as protocol adherence, and outcomes are often trend lines of changes in patient outcomes measured from before to after the implementation. The problem is that the EBP process is strong, the evaluation is minimal, and the translational research opportunities have not been realized.

With the guidance of a research mentor, EBP teams can use the product of their project, the best practice protocol, as the foundation for a translational research project. Establishing a differentiation between the products of the EBP process and translational research allows nurses to see the difference between EBP and research. At the same time, aligning the EBP project and the translational research project has several benefits for the healthcare organization. It extends the impact of the time-consuming EBP process, and resource use is maximized as the review of literature and intervention development for a research project are already accomplished in the EBP project. In addition, use of appropriate research methods makes the results more credible. The results are informative locally in terms of outcomes achieved and learning about the effectiveness of the selected implementation strategies that can be applied to future EBP and translational research projects. The results related to both outcomes and implementation issues will be of interest to the broader nursing practice audience engaged in similar efforts.

An aligned model for EBP and translational research is presented in [Figure 2](#). The linking of EBP with translational research should be conceptualized from the outset of the project. The process starts with the EBP process, progressing through

development of the EBP guideline/best practices protocol (or identification and specification of an innovation to be implemented). At the completion of best practices protocol development, the emphasis shifts to implementation. While EBP evaluation can be accomplished by evaluation of protocol adherence and pre-post measurement of changes in patient outcomes, the use of a more rigorous translational research design that includes both comparative effectiveness methods and study of implementation context should yield better information about what works and what factors influence outcomes.

## Useful Translational Research Designs for Nurses

There are a number of research designs that can be used in translational research. All focus on comparative effectiveness of the new EBP or innovation protocol compared with the current practice protocol. The criterion standard for comparative effectiveness research is a randomized controlled trial with random selection of patients and random assignment to intervention and control groups. It is difficult in nursing practice settings to implement this type of study when the project is to be tested by clinical nurses who are trained in the new protocol. If nurses trained in the new protocol are assigned to patients who will receive the new EBP and those receiving care under the current protocol, there will be cross contamination as the new protocol elements may be used with current protocol (control) patients. In clinical practice, most often new protocols are implemented at the unit level-all nurses are trained. However, translational research design teams have options for creating research protocols. For example:

1. Stepped protocol implementation. Studies can be designed where some nurses are trained prior to others, with staggered or stepped implementation of the protocol.<sup>22</sup> The comparison of outcomes of interest is between the early implementation group and preimplementation phase of later implementation groups.

2. Comparing separate cohorts. Before-and-after implementation designs use separate cohorts of patients to compare baseline preimplementation and postimplementation groups. In these designs, it is important that nurse training for implementation occurs in a window of time between the preimplementation and postimplementation groups, so that the effect of the training period does not contaminate either group. In addition, implementation of any new procedure has a learning curve as new practices become familiar. The early postimplementation period should be considered for exclusion, so that new best practice protocol becomes the new standard care practice. In the analysis, control variables including patient characteristics are included to account for differences between the before-and-after cohorts.

3. Cluster implementation. In hospitals with 2 similar units, a unit-level comparison can be designed where 1 unit implements the new best practice protocol and the control unit continues use of the current practice protocol with no training in the new protocol. A difference-in-differences analysis <sup>23</sup> is used to determine if patient outcomes on the implementation unit change from the baseline preimplementation period to postimplementation, while measuring and subtracting any change over the same period in patient outcomes on the control unit. This type of research design makes the preimplementation and postimplementation comparison design stronger by accounting for unmeasured systematic changes within the organization, evident in changes in patient outcomes on the control unit in the absence of the intervention, that may affect both units.

In all of the study designs outlined above, attention must be paid to using analytic models that control for confounding factors impacting outcomes, including patient characteristics, diagnosis, length of stay, or other interventions that could also affect outcomes.

## Integrating Implementation Science in Translational Research

Integrating implementation science principles within translational research permits identification of aspects of the intervention that can impact the effectiveness of the intervention. Saunders et al <sup>24</sup> identified several aspects of program evaluation that can be used in measuring the process aspects of implementation of an EBP or new innovation protocol ([Table 1](#)).

Quantitative evaluation of the implementation process produces important metrics to determine the penetration of the intervention processes to nurses and patients. In addition, detailed qualitative descriptions of the implementation context are equally important to interpretation of the findings and to replicability of implementation processes in other practice settings. Specific areas of context to be considered in planning and evaluating implementation of EBP/innovation protocols in translational research include 1) the characteristics of the intervention itself, such as burden to patient and nurse, competing demands, and

ultimately fidelity to the intervention; 2) characteristics of the individual providers and patients; 3) the inner (or internal) context, specifically the unit setting and culture where implementation takes place, with its barriers and facilitators; 4) the outer context including hospital-level organizational factors and culture impacting practice, such as visible administrative support; and 5) the planning and processes of the implementation plan, including training, monitoring, and boosting at intervals during implementation and attention to sustainability.<sup>21</sup> Formative evaluation, including interviews with stakeholders, will provide rich data for improvement of processes during the implementation to ensure high fidelity to the newly implemented protocol and for planning implementation of new EBP protocols or innovations. Interviews should include members of the interdisciplinary healthcare team and the recipients of care and their family members. Summative quantitative and qualitative evaluations can provide learning opportunities for future projects.<sup>21</sup>

## Implications for Nurse Leaders

Hospitals with active nursing research programs including Magnet hospitals and those aspiring to Magnet designation should become laboratories for studying translation of EBP best practice protocols into practice. Using translational implementation science methods as the primary platform for hospital-based research leverages the strengths of Magnet organizations in exemplary nursing care. Implementing and researching the processes and impact of exemplary care practices provide foundational knowledge that is useful locally for documenting process improvement and excellence in outcomes. Findings from translational research also inform the broader practice community about innovations and methods fostering practice and outcome improvement. Rather than conducting EBP and research projects as separate efforts on different topics, nurse leaders should recommend aligning these 2 types of projects for maximum impact and efficiency locally and for the broader practice community. By aligning EBP projects with rigorous translational research, organizations will place themselves at the leading edge of practice-based knowledge development through validation of best practices in real-world settings and discovery of the implementation processes that promote achievement of best practice outcomes.

## References

1. Morris ZS, Wooding S, Grant J. The answer is 17 years, what is the question: understanding time lags in translational research. *J Royal Soc Med*. 2011;104(12):510-5203
2. National Center for Advancing Translational Sciences, National Institutes of Health. <https://ncats.nih.gov/>. Accessed February 28, 2018.
3. Harvard Clinical and Translational Science Center. <http://catalyst.harvard.edu/pathfinder/>. Accessed February 28, 2018.
4. Wolf G, Finlayson S, Hayden M, Hoolahan S, Mazzoccoli A. The developmental levels in achieving Magnet(R) designation, part 1. *J Nurs Adm*. 2014;44(3):136-141.
5. Drenkard K. The business case for Magnet(R). *J Nurs Adm*. 2010;40(6):263-271.
6. Drenkard K. The value of Magnet(R). *J NursAdm*. 2013;43(10 suppl):S2-S3.
7. McLaughlin MK, Gabel Speroni K, Kelly KP, Guzzetta CE, Desale S. National survey of hospital nursing research, part 1: research requirements and outcomes. *J Nurs Adm*. 2013;43(1):10-17.
8. Carter EJ, Mastro K, Vose C, Rivera R, Larson EL. Clarifying the conundrum: evidence-based practice, quality improvement, or research?: The clinical scholarship continuum. *J Nurs Adm*. 2017;47(5):266-270.
9. Johantgen M, Weiss M, Lundmark V, et al. Building research infrastructure in Magnet(R) hospitals: current status and future directionse. *J Nurs Adm*. 2017;47(4):198-204.
10. American Association of Colleges of Nursing Essentials of Masters Education in Nursing. 2011. <http://www.aacn.nche.edu/education-resources/MastersEssentials11.pdf>. Accessed February 28, 2018.
11. American Association of Colleges of Nursing. The Essentials of Doctoral Education for Advanced Nursing Practice. 2006. <http://www.aacnursing.org/Portals/42/Publications/DNPEssentials.pdf>. Accessed February 28, 2018.



12. Kelly KP, Turner A, Gabel Speroni K, McLaughlin MK, Guzzetta CE. National survey of hospital nursing research, part 2: facilitators and hindrances. <i>J Nurs Adm.</i> 2013;43(1):18-23.
13. American Association of Colleges of Nursing and Manatt Health. Advancing Healthcare Transformation: A New Era for Academic Nursing. 2016. <a href="https://www.manatt.com/getattachment/d58fee3a-2eb1-4490-82d5-94b94d0d5331/attachment.aspx">https://www.manatt.com/getattachment/d58fee3a-2eb1-4490-82d5-94b94d0d5331/attachment.aspx</a> . Accessed February 28, 2018.
14. Sackett KL, Rosenberg WM, Gray JA, Haynes RB, Richardson WS. Evidence-based medicine: what it is and what it isn't. <i>BMJ.</i> 1996;312:71-72.
15. Melnyk BM, Fineout-Overholt E. <i>Evidence-Based Practice in Nursing and Healthcare: A Guide to Best Practice.</i> 2nd ed. Philadelphia, PA: Lippincott Williams & Wilkins; 2011.
16. Titler MG, Kleiber C, Steelman V, et al. The Iowa model of evidence-based practice to promote quality care. <i>Crit Care Nurs Clin North Am.</i> 2001;13(4):497-509.
17. Fogarty International Center Advancing Science for Global Health, National Institutes of Health. <a href="http://www.fic.nih.gov/News/Events/implementation-science/Pages/faqs.aspx">http://www.fic.nih.gov/News/Events/implementation-science/Pages/faqs.aspx</a> . Accessed February 28, 2018.
18. Smith JL. <i>Evaluation Methods in Implementation Research: An Introduction.</i> 2011 <a href="http://www.hsrd.research.va.gov/for_researchers/cyber_seminars/archives/video_archive.cfm?SessionID=372">http://www.hsrd.research.va.gov/for_researchers/cyber_seminars/archives/video_archive.cfm?SessionID=372</a> . Accessed February 28, 2018.
19. Stetler CB, Legro MW, Wallace CM, et al. The role of formative evaluation in implementation research and the QUERI experience. <i>J Gen Intern Med.</i> 2006;21(suppl 2):S1-S8.
20. Rycroft-Malone J. The PARIHS framework-a framework for guiding the implementation of evidence-based practice. <i>J Nurs Care Qual.</i> 2004;19(4):297-304.
21. Consolidated Framework for Implementation Research (CFIR). <a href="http://cfirguide.org">http://cfirguide.org</a> . Accessed February 28, 2018.
22. Woertman W, de Hoop E, Moerbeek M, Zuidema SU, Gerritsen DL, Teerenstra S. Stepped wedge designs could reduce the required sample size in cluster randomized trials. <i>J Clin Epidemiol.</i> 2013;66(7):752-758.
23. Dimick JB, Ryan AM. Methods for evaluating changes in health care policy: the difference-in-differences approach. <i>JAMA.</i> 2014;312(22):2401-2402.
24. Saunders RP, Evans MH, Joshi P. Developing a process-evaluation plan for assessing health promotion program implementation: a how-to guide. <i>Health Promot Pract.</i> 2005;6(2):134-147.



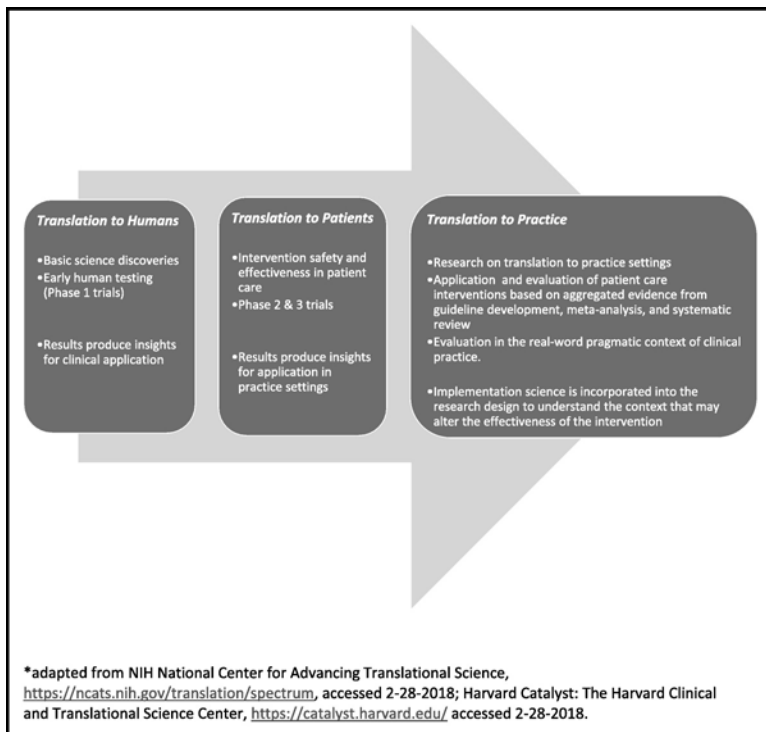


Figure 1. Progression of nursing research from discovery to delivery in practice settings\*.

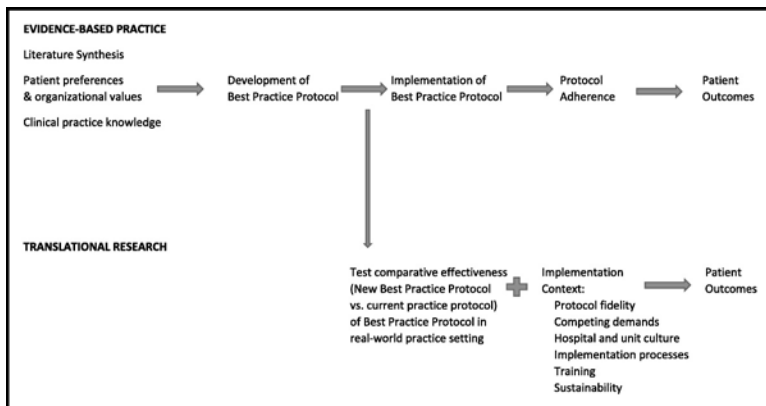


Figure 2. The relationship of EBP and translational research.

Table 1. Implementation Evaluation Components and Example Measures

Implementation Component	Aspect	Metric
Fidelity	Intervention implemented as planned	<ul style="list-style-type: none"> <li>Nurse adherence to protocol</li> </ul>
Completeness	Dose of the intervention delivered	<ul style="list-style-type: none"> <li>Mean no. of intervention components completed per patient</li> </ul>
Exposure	Dose of intervention received by the patient	<ul style="list-style-type: none"> <li>% of eligible patients who received the intervention</li> </ul>
Satisfaction	Participant satisfaction with program, intervention components, interactions	<ul style="list-style-type: none"> <li>Nurse satisfaction with training in intervention</li> <li>Patient satisfaction with delivery of the intervention</li> </ul>
Reach	Participation rate; Barriers to participation	<ul style="list-style-type: none"> <li>% of eligible patients with any component of intervention</li> <li>% of eligible patients refusing to participate</li> <li>% of eligible nurses participating in training in protocol</li> <li>% of eligible nurses performing the intervention with patients</li> <li>Descriptive data on reasons for nurse and patient nonparticipation</li> </ul>
Recruitment	Procedure to recruit and retain participant	<ul style="list-style-type: none"> <li>% of patients contacted or screened who agreed to participate</li> <li>% of patients who enrolled who completed all phases of the study</li> </ul>
Context	Aspects of the environment that can influence the implementation group or contaminate the control group	<ul style="list-style-type: none"> <li>Descriptive data on the implementation and control settings</li> <li>Changes occurring in the implementation and control settings and periods during the study that may affect outcomes</li> </ul>

<sup>a</sup>Adapted from

Table 1. Implementation Evaluation Components and Example Measures

Implementation Evaluation Components <sup>a</sup>	Aspect measured	Metric
Fidelity	Intervention implemented as planned	<ul style="list-style-type: none"> <li>Nurse adherence to protocol</li> </ul>
Completeness	Dose of the intervention delivered	<ul style="list-style-type: none"> <li>Mean no. of intervention components completed per patient</li> </ul>
Exposure	Dose of intervention received by the patient	<ul style="list-style-type: none"> <li>% of eligible patients who received the intervention</li> </ul>
Satisfaction	Participant satisfaction with program, intervention components, interactions	<ul style="list-style-type: none"> <li>Nurse satisfaction with training in intervention</li> <li>Patient satisfaction with delivery of the intervention</li> </ul>
Reach	Participation rate; Barriers to participation	<ul style="list-style-type: none"> <li>% of eligible patients with any component of intervention</li> <li>% of eligible patients refusing to participate</li> <li>% of eligible nurses participating in training in protocol</li> <li>% of eligible nurses performing the intervention with patients</li> <li>Descriptive data on reasons for nurse and patient Nonparticipation</li> </ul>
Recruitment	Procedure to recruit and retain participant	<ul style="list-style-type: none"> <li>% of patients contacted or screened who agreed to participate</li> <li>% of patients who enrolled who completed all phases of the study</li> </ul>
Context	Aspects of the environment that can influence the implementation group or contaminate the control group	<ul style="list-style-type: none"> <li>Descriptive data on the implementation and control settings</li> <li>Changes occurring in the implementation and control settings and periods during the study that may affect outcomes</li> </ul>

Adapted from Saunders et al.<sup>24</sup>