

# Feed Forward Systems for Patient Participation and Provider Support: Adoption Results From the Original US Context to Sweden and Beyond

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**Background:** This is a study of 2 clinical feed forward systems (FFSs) situated in different contexts: in the United States, where the system was developed, and in Swedish clinical settings, where it was first adopted. Both systems were identified as clinically successful despite differing contexts, and the objective of this study is to understand what essential properties determined their success. **Methods:** In our search for essential properties of the FFS, we used acceptance, use, and utility as indicators in questionnaires and interviews of patients and providers. Properties were identified as essential if they enabled reinforcing loops favorable for patients, providers, or both at clinical encounters. **Results:** A total of 44 patients participated in each context, along with 13 providers from the United States and 6 providers from the Swedish clinics. In the patient questionnaire, a majority of patients rated their impression of the FFS as excellent to good (United States: 84%, Sweden: 96%,  $P < .001$ ). Interviews with both patients and providers indicated that the FFS patient overview displaying structured data previous to the clinical encounter is favorable. These essential properties enabled patient involvement through engagement, education, and communication with the provider, who appreciated them as time-saving for managing data and as decision support. **Discussion:** Despite distinctly different contexts and locally adapted content, essential properties that induced successful patient participation and provider support were identified as universal in the FFSs. Thus, further spread of the FFS may be enabled to accomplish patient-centered care and improved clinical information and quality management.

Key words: *decision support, feed forward, patient-physician relationship*

“**F**eed forward is the modification or control of a process by its anticipated or predicted results or effects.”<sup>1(p929)</sup> Feed forward systems (FFSs) are common in industrial or commercial settings and have been increasingly developed for application in health care settings. The first known FFS for clinical use was developed and implemented at the Spine Center of Dartmouth-Hitchcock Medical Center (DHMC) in 1999.<sup>2</sup>

The DHMC clinical FFS was intended to provide a “common language” for patients and providers that would better enable communication about patients’ current health status, their treatments, and

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response to therapy. This system provides a consistent method for (a) establishing a plan of care that matches the patient's evolving health needs, (b) creating a standard method for tracking patients' longitudinal health outcomes using both generic and disease-specific measures, and (c) generating health data "streams" on health status, patient characteristics, and given treatments.<sup>3-7</sup> These data can be used for improving care, conducting observational clinical research, and tracking patient outcomes as they evolve. Furthermore, the data can be used in clinical collaborative networks for assessing comparative performance across centers and for conducting multicenter research.<sup>3-7</sup>

The Swedish Rheumatology Quality (SRQ) registry<sup>8</sup> is a prospective, multicenter, specialty-oriented, practice-based, longitudinal database in place since 1996. It is designed for patients with rheumatoid arthritis meeting a set of formal diagnostic criteria<sup>9</sup> and includes a core set of rheumatoid arthritis-related outcome measures.<sup>10</sup> The DHMC clinical FFS serves as the model in Sweden for a Web-based, national data registration to monitor the quality of arthritis management. The FFS was first incorporated as a component of the SRQ in 2003.

FFSs are integrated into the process of care delivery and begin with data entry by patients on health-related concerns including pain, swollen, and tender joints and work-related disability. Swedish patients with arthritis can access the SRQ prior to meeting with the provider via the Internet from any location. Upon arrival at the clinic, patients' responses to additional questions about their current health status are downloaded into the system. Before meeting the provider, previously entered data are compiled into a summary page that provides a graphical representation of patients' health status as followed over time by composite measures reflecting multiple aspects of health. Health care providers often use the summary page as a decision support tool during the clinical encounter.

The organization of the summary page is an important feature of the system. At the DHMC Spine Center, the summary page is based on the Clinical Value Compass framework, a measurement system that quantifies the quality and results of care in

4 key dimensions: (1) functional status, risk status, and well-being; (2) costs; (3) satisfaction with health care and perceived benefit; and (4) clinical outcomes.<sup>11,12</sup> Unlike the DHMC system, the SRQ summary page provides longitudinal data that allow patients to review their disease course and evidence of response to treatments over time. In addition, the SRQ summary page does not report costs or patient satisfaction.

The 2 FFSs described above are situated in 2 distinctly different national contexts and have both operated successfully in their respective setting. Because contextual factors are thought to influence successful implementation of health information technology innovations,<sup>13-18</sup> efforts to examine the "implementation context" can be highly informative in guiding further dissemination of such systems. It is therefore interesting to find those elements or essential properties that these systems possess that have enabled their success in distinctive clinical contexts embedded within 2 substantially different health care systems (United States and Sweden). Thus, the aim of this research project is to identify and describe the essential properties of the FFS, using *acceptance*, *use*, and *utility* as indicators. Specifically, we explore 2 main questions: What are the patients' perceptions? and What are the providers' perceptions about the acceptance, use, and utility of the FFS at the 2 different sites? Insights into the essential properties of FFS that promote positive perceptions in both settings are used, in turn, to propose strategies that might aid future dissemination of the FFS as a tool for quality management in other settings.

## METHODS

### Study settings

This study, conducted from 2004 to 2006, includes patients and providers from 2 contexts: a US clinic (DHMC, Spine Center) and 2 Swedish clinics (rheumatology clinics at the Karolinska University Hospital and at Sahlgrenska University Hospital). The Spine Center is a clinical service area within DHMC, a large, multifacility academic medical center located in rural, southern New Hampshire. The Spine Center at DHMC serves as a regional

referral center<sup>19</sup> and provides health care in more than 15 000 patients' visits annually. The Swedish rheumatology clinics belong to the 2 largest university hospitals in Sweden. Sahlgrenska University Hospital is situated in Göteborg, the second-largest city in Sweden, after Stockholm, where Karolinska University Hospital is based. The clinic at Sahlgrenska University Hospital provides health care in more than 17 000 patients' visits annually compared with an annual volume of 24 000 patients' visits at Karolinska University Hospital. Despite differences in geographical location within Sweden, the Sahlgrenska and Karolinska University Hospitals are both organized and administered under the authority and supervision of the ministry of health. In addition, the design and implementation of the FFS at both sites was highly similar. Given these similarities, we chose to consider the 2 Swedish sites as a single entity in our analysis.

### Participants and data sources

At both the US clinic and Swedish clinics, consecutive patients were approached for study participation upon arrival to the clinic and while waiting to see their provider. Nurses or administrators asked pa-

tients if they were willing to participate, and if so, patients proceeded with the questionnaire and then the interview. Informed consent was obtained verbally. Health care professionals providing care to sampled patients were asked to participate in the study.

The patient questionnaire and the semi-structured patient interview guide were constructed and pilot-tested at the Karolinska University Hospital on a sample of 10 patients to identify item ambiguity and to further refine question wording; these data were not included in the analysis. The patient questionnaire as well as the patient and provider interviews were translated into English and grammatically reviewed at the Spine Center before the study at DHMC was initiated. Minor adjustments were made to the questionnaire to reflect differences in the implementation of the FFS at study sites (Table 1).

### Data collection

Data collection at the US clinic was conducted daily and lasted for 2 consecutive weeks in spring 2005. Because work schedules varied among providers at the Swedish clinics, data were collected only on days on which participating providers were present in the clinic during the spring of 2004 to 2006.

**Table 1**

IMPLEMENTATION CHARACTERISTICS OF 2 FFSS, BY SETTING

Characteristic	US clinic	Swedish clinics
Duration of FFS use	6 y	2 y
Health questionnaire, level of detail (time required to complete data entry by most patients)	Extensive (15–30 min)	Brief (5–15 min)
Key features of the summary page	Organized according to the Clinical Value Compass framework <sup>a</sup>	Longitudinal data showing disease course and response to therapy
Patient-specific		
Participated in use of the FFS	All patients	Mostly patients with recent onset of rheumatoid arthritis
Proportion of patients offered access to the summary page	25%	100%
Provider-specific		
Timing of data entry into the system	After visit	During visit

Abbreviation: FFS, feed forward system.

<sup>a</sup>The value compass framework is a measurement system that measures patient functional status, risk status, and well-being; costs of care; satisfaction with healthcare and perceived benefits; and clinical outcomes.

Questionnaires were administered after the use of the FFS, and semi-structured interviews were conducted after the visit. The patient questionnaire, consisting of closed- and open-ended items, sought to reveal essential properties that promoted acceptance, use, and the general utility of the feed forward system. Two items assessed system acceptance (*What is your overall impression of the system? Would you like to enter any other information that the system did not ask about?*). Three items assessed use (*Was it easy or difficult to understand how to progress through the system? Did you experience any problems when entering data? Would you appreciate the opportunity to enter data prior to your appointment?*) and 1 item assessed utility (*What do you feel are the advantages and disadvantages of the FFS?*). Response categories included 5-point Likert ratings, yes/no answers, and free text as appropriate to the item. Following each question and at the end of the questionnaire, the patient had the opportunity to write general comments.

Patient interviews at the US clinic and the 2 Swedish clinics differed in terms of the number of stem questions used to reflect differences in the use of the FFSs across sites. The purpose of these questions was the same as in the questionnaires and therefore paralleled their content:

1. How did the FFS influence the visit?
2. Was the visit different in any way? What influence or impact do you think that the system had on the interaction between you and your provider?
3. What do you think was the provider's opinion of the FFS?

In interviews with providers, we followed a similar approach by using 6 broad questions:

1. How does the use of the FFS affect your work routines?
2. What long-term effects (eg, for the patients, clinical, local/regional outcomes, and other factors) are observed by using the FFS?
3. What changes would you want to make to the FFS?
4. What advantages does the FFS possess?
5. What disadvantages does the FFS possess?
6. What are patients' opinions of the FFS?

At the end of interviews with both patients and providers, we requested comments on issues related to system use, acceptability, and utility that they felt were important.

Following sessions with both patients and providers, the principal investigator (H.H.) generated extensive field notes that contained reflections on interview content related to the study objectives and other observations that seemed relevant (eg, body language of respondents and other nonverbal cues). All interviews in the United States were audiotaped to confirm and augment the content of field notes and to enable more complete translation of comments that arose during the semi-structured interviews as necessary.

### Analysis

We used both qualitative and quantitative data to identify and confirm the presence of themes directly related to the acceptance, use, and utility of the system from the perspective of the consumer and provider of health care services. By using several methods to investigate the FFS from different perspectives, we have tried to achieve triangulation.<sup>20</sup> Our sample of providers was fixed; thus, these qualitative results must be regarded as exploratory in nature.

When studying a phenomenon such as the FFS without a theoretical framework as background, inductive approaches are usually applied.<sup>21</sup> We therefore used content analysis in an iterative way by continually seeking, confirming, and refuting evidence for potential themes in our data.<sup>22</sup> Content analysis can be used when the goal is to provide knowledge and insight of a certain phenomenon. Of the 3 distinct approaches to content analysis identified by Hsieh and Shannon,<sup>23</sup> we used the "conventional" approach suitable for analysis of phenomena in which few theories or previous research exists.

All taped interview material and field notes from both contexts were transcribed to allow immersion in the data. Data were then condensed, coded, and categorized, and emergent themes were identified. To strengthen the credibility of the results,<sup>24</sup> examples of text thought to reflect these themes were discussed

among research team members until consensus was achieved. Through our indicators, we found themes or essential properties that we compared between the sites. Overall, themes were similar at both sites apart from aspects of problems related to language difficulties or participant literacy at the US clinic and early implementation obstacles in the Swedish clinics. These themes were converted into essential properties if the theme identified gave rise to reinforcing loops that were favorable for patients, providers, or both. Reinforcing loops are virtuous cycles and defined here as loops in which the interconnected parts add on each other generating positive outcomes.

Questionnaires provided complementary quantitative ratings of perceived acceptance, use, and utility of the system following its actual use. We analyzed these data using the Fisher's exact 2-tailed test to compare response patterns among patients at both sites. A *P* value of less than .05 was used as the threshold for statistical significance. No clinical outcomes were assessed in this study.

## RESULTS

Eighty-eight patients participated in this study (44 in the US clinic and 44 at both Swedish clinics). In addition, 13 providers from the US clinic and 6 providers from the Swedish clinics participated. Of patients at the US clinic and Swedish clinics, 55% and 70% were women, respectively. All participating providers in the Swedish clinics were MDs, and in the US clinic, 9 of the providers were MDs, 2 were physiotherapists, and 2 were nurse practitioners.

### Patient questionnaire

The overall impression of the FFS was favorable according to a majority of patients (Table 2). An opportunity to enter data from home or work prior to coming to the clinic was appreciated by many patients, but somewhat more so in Sweden ( $P = .075$ ). Patients' familiarity with using computers varied widely between both settings ( $P = .004$ ).

In response to open-ended questions, a few patients identified additional data elements that they felt were relevant and important to their current health status

**Table 2**

PATIENT PERCEPTIONS OF USING A FEED FORWARD SYSTEM, BY SETTING

	<b>Patients at US clinic (N = 44)</b>	<b>Patients at Swedish clinics (N = 44)</b>	<b>P</b>
Familiarity with the use of computers			<.01
Very familiar	34	27	
Familiar	27	59	
Not familiar	39	14	
Willingness to enter data prior to appointment			.08
Yes	41	61	
No	45	23	
Had no computer	14	16	
Overall impression of the system			<.001
Excellent	14	30	
Very good	45	66	
Good	25	0	
Fair	9	2	
Poor	7	0	

or diagnosis, but that were not requested by the FFS. At the US clinic, patients voiced interest in providing more detailed explanations to some questions in which the fixed answers did not suffice. Responses to a final open-ended question on advantages and disadvantages of the FFS demonstrated numerous overlapping perceptions across sites (Table 3).

### Patient interview

Patient participation in the interviews was much lower at Swedish clinics (40% vs 100% at the US clinic). Swedish nonparticipants cited unawareness of the opportunity to participate and lack of time due to scheduled activities after the visit as major reasons.

### Patients' perceptions of provider acceptance

Patient perceptions of providers' opinions were largely similar in both settings. The majority of patients had neutral opinions at both sites. In the US

**Table 3**

PATIENTS' PERCEPTIONS OF ADVANTAGES AND DISADVANTAGES OF THE FEED FORWARD SYSTEM, BY SETTING

Patients at the US clinic	Patients at the Swedish clinics
Advantages—similar comments No paper work Quick, saves time Very easy system to use Saves time for physicians. Everything goes directly to the physician	No paper work Quick Easy and efficient My physician does not have to enter my data, I do it myself
Advantages—dissimilar comments The laptop is a very good tool to save time and makes the process move along more quickly Makes you think about your health Possibly finds other problems Confidential More convenient Asks the same questions in different ways; complete The health survey got me thinking about why I was here and my needs	Gives the patient more time with the provider  Clear Easy overview Easy to follow-up; you can easily see progress You can see the effect of your treatment. I have the same data and information as my physician When used at home I could spend more time with the questions and looking at the overview It helps me remember what to talk to my physician about
Disadvantages—similar comments Takes a little extra time Difficult for seniors The laptop reacted slowly to pen pressure	Takes time for both provider and patient Difficult for seniors The touch screen did not react to pressure
Disadvantages—dissimilar comments Health survey was too long  Repetitive questions Unable to give alternative answers or descriptions.	I was not informed that I was going to enter data before my visit to the provider  Time is important; I would like to enter data in peace and calm
Answers offered are not detailed enough Difficult to apply certain questions Questions are worded strangely Too generic. Impersonal	I would like more privacy when I enter my data Somewhat difficult to move forward in the system  Ergonomics is important at the touch screen station

clinic, a little more than a third of the patients perceived the providers' opinions as positive. In the Swedish clinics, two-fifths of the patients perceived the provider's opinions as positive. No patient perceived negative provider opinion about the FFS at either site.

### Use

Slightly less than half of all patients at both the US clinic and Swedish clinics thought that there were changes in their interaction with the providers as

compared with their visits to providers at other clinics they attended. Approximately one-third of these patients at both sites felt that FFS-facilitated interactions were positive, saying that

The system makes it possible for the provider and I to talk about the important issues. (Swedish patient)

It feels safe to register data before the meeting and it facilitates the visit and what we need to focus on. (Swedish patient)

The visit became very helpful, thorough and informative. (US patient)

The visit went more quickly by asking all the questions beforehand, the provider already had all the data he needed. (US patient)

I remembered things I wanted to bring up with my provider when answering the questions, it worked as a reminder. (US patient)

The survey made me think of my overall health. (US patient)

### **Utility**

The summary page was deemed very valuable by the majority of patients to whom it was shown. In the US clinic, 11 patients were shown the summary page and all appreciated it. In the Swedish clinics, all patients were shown the summary page and of the 17 patients interviewed, 1 patient had not had the time to go through it and 16 appreciated it, when asked they responded

It is easy to see how I have responded to treatment and how I felt last year. (Swedish patient)

Most important was that the provider compared my results from a previous visit. (US patient)

Patients attending one of the Swedish clinics complained of lack of preparation, awareness, and time for the feed forward health survey, while both patients and providers at the US clinic commented on the length and repetitiveness of the feed forward health survey and occasional lack of applicable response alternatives.

### **Provider interview**

#### ***Providers' perception of patient acceptance***

Providers reported that most patients found the FFS useful and positive. They also anticipated that patients with lower literacy levels or language difficulties might have problems using the FFS.

Older patients might have problems using the system whereas it comes naturally for younger patients. (Swedish provider)

Only a small percentage disapproves of using the system. Mostly they understand that we are all helped by it. (US provider)

Patient benefits, from the providers' point of view, were easier acceptance of the disease, greater involvement in self-management, and a better understanding of their disease and treatment.

Hidden information that the patient have may unexpectedly surface. (Swedish provider)

Patient gets more involved in their care—that helps the treatment. (US provider)

### **Use**

Providers at the US clinic reported, after 6 years of use, that the FFS was of immense importance for both follow-up and feedback. All providers at the 2 different clinics in Sweden, after 2 years of use, reported that the FFS was a valuable tool for follow-up and overview and was an important quality instrument.

Work is smoother, it is much easier to form an opinion and decisions are easier to make. (Swedish provider)

Without the FFS, we can't give the patient feedback. (US provider)

Approximately, half of all providers at the 2 different sites, US clinic and Swedish clinics, stated that working with the system saved time, whereas the other half said it added time.

When working with the system for a while you start saving time. (Swedish provider)

Though working with the system adds extra time I understand the greater good of it. (US provider)

Most providers agreed that the summary page made it easier to see improvement and progress, and it

facilitated decision making regarding treatment since comparisons were easy and work gets more structured. The FFS provided a specific common language for promoting better communication.

The summary overview helps me deciding upon treatment and the next step to take. (Swedish provider)

It (the FFS) makes treatment better by benchmarking. (Swedish provider)

The summary is very good to look at before you meet with a new patient. (US provider)

The health questionnaire results act like a channel for communication. (US provider)

### **Utility**

The FFS was observed to have the potential to influence health care processes in the short term as well as in the long term:

Benchmarking within and across patient groups, between clinics and institutions are possible. (Swedish provider)

Now we are able to give our patients higher quality of care. (US provider)

This changes how health care is delivered. (US provider)

### **Additional insights**

Some providers felt that the utility of the system could be improved

A connection to the electronic medical record would reduce time to register data. (Swedish provider)

More diagnoses and variables could help us include more patients. (Swedish provider)

A function that asks patients if they would like to have the questions read to them could

help, can be made in different languages. (US provider)

Additional insights about the potential value of the FFS arose from comments by patients and providers at both sites and were similar in nature.

Questions come up that I don't think would have without the system. (Swedish patient)

The summary page gives a concrete picture of how I've actually been feeling which I think helps the doctor to understand my situation better. (Swedish patient)

We can collect data to see results that were not predicted before. (US provider)

It is easier to talk about sensitive issues such as mental status. (US provider)

The survey helps me think about questions that I wouldn't think of bringing up with my provider otherwise. (US patient)

## **DISCUSSION**

This study shows high levels of perceived acceptance, use, and utility among patients and providers of the original clinical FFS and its first sister system. We found essential properties, shared across distinctly different contexts that appeared to induce patient participation and provider support in ways that may decrease the effect of differences in context and increase satisfaction with care and the quality of services being delivered. These essential properties seemed to support patient centeredness reflected by greater patient participation and engagement in the clinical encounter, patient education, and empowerment through the provision of information feedback over time on disease course and response to therapy and a more active role for patients in their self-management. Across the study settings, these essential properties appeared equally important and have the potential to contribute to better quality management elsewhere.

Interesting similarities were observed in patients' and providers' opinions about the shared and essential properties of these 2 FFSs. The effective way to perform the visit by gathering data beforehand was appreciated and considered time-saving by most patients and providers. The structured way to assess the disease with a patient overview to support decisions about treatment and follow-up of treatment results was considered very useful. The clinically structured decision support characteristics of these feed forward processes also entailed that this is an advantageous strategy for the implementation of evidence into practice. When this decision support was shared with patients, it was found helpful by an absolute majority. After 6 years of use at the US clinic and after 2 years of experience in Swedish clinics and despite wide differences in the clinical settings, the FFS still worked as intended<sup>2</sup>—and with high levels of patient and provider satisfaction. The regular way of performing the clinical visit is not altered to a significant extent by the introduction of the FFS. Thus, the threshold for acceptance by providers may be lowered and facilitates implementation of the feed forward process for organizing a visit.

In addition to a number of key similarities in perceived strengths of the system, we also observed differences in opinions about divergent system characteristics in the 2 contexts. Some of these may relate to differences in the process of organizing the system at each site, regarding, for example, the patients' opinions of the summary page and providers' work with the summary page.

We found quite unexpected opinions offered by patients and providers, yielding additional insights that may be elusive in systematic studies by using a standardized interview guide or fixed-response questionnaires. We find these comments intriguing as they may represent tacit knowledge<sup>25</sup> that appears due to a need in the clinical situation, in contrast to the explicit knowledge provided by the structured FFSs. Contrary to the view that forcing uniform clinical use of a structured measurement system might be restrictive, this system opened up new opportunities that would not have existed without the FFS. This was observed in both the different contexts and should

be looked for when the FFS is introduced in further clinical settings.

The study design used quantitative and qualitative methods without control groups with ensuing restricted generalizability. However, when combining these methods for data collection and analysis, dependence on control groups is reduced. Both settings were studied during spring or early summer; therefore, seasonal bias cannot be excluded. Despite some significant findings (Table 2), the small number of participants might limit the power of the quantitative portion of our analysis. Moreover, even though theme saturation was achieved in some instances, we may have missed additional emerging themes since only a few providers in Sweden worked with the FFS at the point of this study. The findings in this first exploratory study show satisfying results in many aspects, but more studies are needed to further investigate the potentials of FFSs and possible improvements of clinical outcomes.

Some uncertainty exists around the extent to which adoption of systems to manage health care quality are influenced by the unique context of the implementation site.<sup>15</sup> Especially organizational, social, and professional contextual factors are found to be barriers to the implementation of evidence, and there is never a guarantee that an innovation that has worked in one context will work in another.<sup>16</sup> The DHMC Spine Center FFS has been successfully adopted by 13 other medical centers that are participating in a randomized controlled trial on spine surgery ("SPORT"), sponsored by the National Institutes of Health.<sup>26,27</sup> The system has also been redesigned as a secure, Web-based system and adapted for use in other clinical programs at DHMC including programs in general internal medicine, occupational medicine, pain management, total joint replacement, breast cancer, and cardiovascular risk reduction. In Sweden, the Web-based feed forward process has now spread from its first site at the Karolinska University Hospital to be adopted by 16 of the 61 outpatient rheumatology clinics throughout the country and is being implemented at another 10. Given evidence of subsequent adoption of these systems at other sites, their properties appear to be relevant across many differing contexts,

allowing wide variation in local adaptation of the feed forward system at the clinical visit.

In conclusion, despite distinctly different contexts and varying adoption, essential properties with a potential to promote more effective quality management through greater patient participation and provider support were identified as generic and the most appreciated in the FFSs studied. These properties include involving patients in structured data collection before the clinical encounter, generating a summary data overview that enables decision support for clinicians and promotes motivation for continued patient self-management. This offers the potential to further develop these systems to enable the core feed forward principle<sup>1</sup> in clinical practice—to modify a process by its anticipated effects.

## REFERENCES

1. Brown L, ed. *The New Shorter Oxford English Dictionary on Historical Principles*. Oxford, England: Clarendon Press; 1993.
2. Weinstein JN, Brown PW, Hanscom B, Walsh T, Nelson EC. Designing an ambulatory clinical practice for outcomes improvement: from vision to reality—The Spine Center at Dartmouth–Hitchcock, year one. *Qual Manag Health Care*. 2000;8(2):1–20.
3. Nelson EC, Batalden PB, Plume SK, Mihevc NT, Swartz WG. Report cards or instrument panels: who needs what? *Jt Comm J Qual Improv*. 1995;21(4):155–166.
4. Nelson EC, Splaine ME, Batalden PB, Plume SK. Building measurement and data collection into medical practice. *Ann Intern Med*. 1998;128(6):460–466.
5. Nelson EC, Splaine ME, Godfrey MM, et al. Using data to improve medical practice by measuring processes and outcomes of care. *Jt Comm J Qual Improv*. 2000;26(12):667–685.
6. Nelson EC, Batalden PB, Homa K, et al. Data and measurement in clinical microsystems, 2: creating a data rich information environment. *Jt Comm J Qual Saf*. 2003;29(1):5–15.
7. Nelson EC, Batalden PB, Godfrey M. *Quality by Design: A Microsystems Approach*. San Francisco, CA: Jossey-Bass; 2007.
8. Carli C, Ehlin A, Klareskog L, Lindblad S, Montgomery SM. Trends in DMARD prescription in early rheumatoid arthritis are influenced more by hospital setting than patient or disease characteristics. *Ann Rheum Dis*. 2006;65(8):1102–1105.
9. Arnett FC, Edworthy SM, Bloch DA, et al. The American Rheumatism Association 1987 revised criteria for the classification of rheumatoid arthritis. *Arthritis Rheum*. 1988;31(3):315–324.
10. Felson DT, Anderson JJ, Boers M, et al. The American College of Rheumatology preliminary core set of disease activity measures for rheumatoid arthritis clinical trials. The Committee on Outcome Measures in Rheumatoid Arthritis Clinical Trials. *Arthritis Rheum*. 1993;36:729–740.
11. Nelson EC, Mohr JJ, Batalden PB, Plume SK. Improving health care, 1: the clinical value compass. *Jt Comm J Qual Improv*. 1996;22(4):243–258.
12. Nelson EC, Batalden PB, Lazar J. *Practice-Based Learning and Improvement: A Clinical Improvement Action Guide*. Oak Brook, IL: Joint Commission Resources; 2007.
13. Chaudhry B, Wang J, Wu S, et al. Systematic review: impact of health information technology on quality, efficiency, and costs of medical care. *Ann Intern Med*. 2006;144(10):742–752.
14. Southon FC, Sauer C, Grant CN. Information technology in complex health services: organizational impediments to successful technology transfer and diffusion. *J Am Med Inform Assoc*. 1997;4(2):112–124.
15. Grol R, Grimshaw J. From best evidence to best practice: effective implementation of change in patients' care. *Lancet*. 2003;362(9391):1225–1230.
16. McCormack B, Kitson A, Harvey G, Rycroft-Malone J, Titchen A, Seers K. Getting evidence into practice: the meaning of "context." *J Adv Nurs*. 2002;38(1):94–104.
17. Greenhalgh T, Robert G, Macfarlane F, Bate P, Kyriakidou O. Diffusion of innovations in service organizations: systematic review and recommendations. *Milbank Q*. 2004;82(4):581–629.
18. Pettigrew AM, Whipp R. *Managing Change for Competitive Success*. Oxford, England: Blackwell; 1993.
19. DHMC Web site. About Dartmouth-Hitchcock Medical Center. [http://www.dhmc.org/webpage.cfm?site\\_id=2&org\\_id=566&morg\\_id=0&sec\\_id=0&gsec\\_id=39&item\\_id=39](http://www.dhmc.org/webpage.cfm?site_id=2&org_id=566&morg_id=0&sec_id=0&gsec_id=39&item_id=39). Accessed February 22, 2009.
20. Holloway I. *A-Z of Qualitative Research in Healthcare*. Oxford, England: Blackwell; 2008.
21. Pope C, van Royen P, Baker R. Qualitative methods in research on healthcare quality. *Qual Saf Health Care*. 2002;11(2):148–152.
22. Krippendorff K. *Content Analysis: An Introduction to Its Methodology*. Thousand Oaks, CA: Sage; 2004.
23. Hsieh HF, Shannon SE. Three approaches to qualitative content analysis. *Qual Health Res*. 2005;15:1277.
24. Lincoln YS, Guba EG. *Naturalistic Inquiry*. Newbury Park, CA: Sage; 1985.
25. Nonaka I. A dynamic theory of organizational knowledge creation. *Organ Sci*. 1994;5(1):14–37.
26. Weinstein JN, Tosteson TD, Lurie JD, et al. Surgical vs nonoperative treatment for lumbar disk herniation: the Spine Patient Outcomes Research Trial (SPORT): a randomized trial. *JAMA*. 2006;296:2441–2450.
27. Weinstein JN, Lurie JD, Tosteson TD, et al. Surgical versus non-surgical treatment for lumbar degenerative spondylolisthesis. *N Engl J Med*. 2007;356(22):2257–2270.