The Internet Journal of Medical Education
Volume 1 Number 2

Quality Improvement Methods for Medical Handoffs

J Joshi, T Best

Citation

J Joshi, T Best. *Quality Improvement Methods for Medical Handoffs*. The Internet Journal of Medical Education. 2009 Volume 1 Number 2.

Abstract

Objectives: We describe the application of fundamental quality improvement methods to medical handoffs in order to improve resident learning and clinical training.Methods: We select six pervasive quality improvement methods that each highlight a particular aspect of overall process improvement. The six methods are the 7-S Framework, Plan-Do-Check-Act, Define-Measure-Analyze-Improve-Control, Lean, Root Cause Analysis, and the Prioritization Matrix.Results: We describe how each method can be used to improve the efficiency and effectiveness of a patient care handoff. Examples are provided throughout to help depict each method in the handoff context. Our exposition is written so as to introduce the methods to a practitioner charged with improving a medical handoff, or a medical educator providing a course on healthcare process improvement.Conclusions: The medical field recognizes the importance of studying other disciplines in order to optimize key processes in medicine. We present six quality improvement methods not universally acknowledged in the medical field that are particularly applicable to improving medical handoffs. By contextualizing these methods into the medical handoff, we show both how to improve the overall process and emphasize the value in implementing concepts from other disciplines as part of the residency training curriculum.

INTRODUCTION

In the ever changing residency environment, clinical departments seek to optimise patient care while simultaneously avoid overworking medical residents. Beginning July 2003, the American Council of Graduate Medical Education (ACGME) developed the duty hour restrictions as one of the means to reduce resident fatigue. Since then, studies conducted on work hour limitations demonstrate positive results on resident performance.[1-5]

Despite the preponderance of positive benefits, the change has produced some potential and unintended consequences.[6] Simulated models estimate increased financial costs and decreased resident teaching time.[7,8] While such analysis may be difficult to ascertain[9]; one certainty is an increase in handoff care from one resident to another.

A foundation in clinical practice, the handoff of care involves understanding and conveying the patient's medical conditions, detailing a plan of action, and communicating this complex set of information efficiently. Limited resident work hours affects the continuity of care and makes a successful handoff all the more imperative.[10] Maintaining a sense of continuity is a major concern among resident physicians[11], and resolving it begins by improving the handoff experience. With new requirements set to begin in July 2011, recognizing how to improve the handoff experience becomes critical.[12] Many published studies advocate modeling the handoff into a standard protocol.[13-19]

Given this need, we seek to contextualize quality improvement (QI) tools into developing the handoff model. In other industries, such quality improvement tools focus on optimizing a firm's capabilities and resources to best produce a product or service. Similarly, the same QI measures can be used to develop an optimal standardised handoff model. We assume the perspective of a QI team focused on improving the handoff through six fundamental quality improvement models: 7-S Framework, Plan-Do-Check-Act (PDCA), Define-Measure-Analyze-Improve-Control (DMAIC), Lean Principles, Root Cause Analysis (RCA), and Prioritization Matrix.

Each model is derived from a core principle that addresses a specific aspect of quality improvement. We arrange the models to address the specific complexity in the order in which the issue typically arises. The 7-S Framework allows the QI team to appreciate how the new handoff will affect the department's intricate structure. PDCA and DMAIC establish models for implementing a QI plan of action. Lean Principles address waste reduction initiatives fostering an efficiency-driven mentality. RCA define the nature and frequency of variations and problems inherent in common handoff models. Finally, the Prioritization Matrix sets up an objective, conflict-resolution model essential in prioritizing the many values and principles a department seeks in a handoff model.

Applying these principles serves as an educational tool to convey improvement opportunities and to recognize potential flaws inherent in the handoff process. These models structure the handoff experience by demonstrating its intricacies and educate residents on how to improve the transition of care.

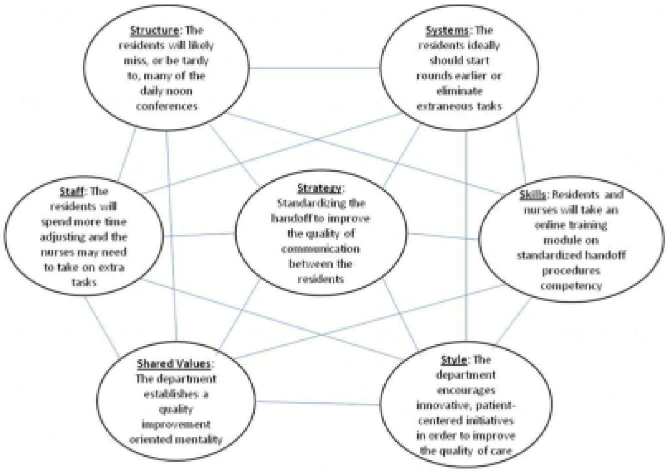
7-S FRAMEWORK

All new handoff programs face conflicts that arise from competing values and varying levels of motivation.[20] Anticipating such issues will prevent them from derailing the change. The 7-S framework[21,22] addresses this by developing a basic understanding of the handoff environment. The 7-S breaks down a work system into seven elements: strategy, structure, systems, skills, staff, style, and shared values.[21]

The team first identifies which of the seven elements is central to the change under consideration. It then establishes links with and among the remaining six elements to create a network depicting the overall repercussions of the change.[21,22,23,24] In general, strategy is the organization's objectives and steps taken to achieve them. This includes the prioritization and allocation of time, staff, and resources. Structure is work system organization (e.g. reporting hierarchy, daily shift assignments). Systems focus on the methods and procedures surrounding the current handoff (e.g. shift-change requirements, training procedures, or even EMR protocols). Shared values are core beliefs. Style is the work system's ambiance, particularly its cultural demeanor. Staff includes the people involved (e.g. physicians and nurses). Skills are the capabilities of the organization as a whole; the medical training and clinical experience garnered by all. See Figure 1 for an example in our context.

Figure 1

Figure 1



Visualizing a 7-S model.Note the intricate relationship among the various factors. Recognise which among these factors represents an improvement opportunity and which factors must remain constant in order to best facilitate acceptance of a new, improved handoff model.

While some conflicts are resolved through clarification of change details and intent, many persist without an adjustment to the original design.[25] For example, suppose the team suggests a patient handoff from a surgical resident to a resident in the recovery suite. Nurses may object to this change, given their current leadership of post-op patient management. In this case it may be best to compromise and split recovery management into tasks for both disciplines. In this example, nurse recovery management could be referred to as a Change Invariant, or an aspect of the current system that should remain for the betterment of the future state.[25,26]

With the 7-S model, one shows the potential changes, and limits thereof, allowing a department to gauge a handoff's efficacy through comprehensive understanding. This ultimately determines the proper course of action to be implemented. Once the environment is understood, the team will need a method to design and implement a new handoff model.

PLAN-DO-CHECK-ACT (PDCA) AND DEFINE-MEASURE-ANALYZE-IMPROVE-CONTROL (DMAIC)

After understanding the environment, the first task for any handoff improvement team is to select a method for designing and implementing a new handoff model. Two methods are Plan-Do-Check- Act (PDCA)[27] and Define-Measure-Analyze-Improve-Control (DMAIC).[28] Both models introduce a broad structure to the change process that is conducive for continuous improvement.[28,29,30,31] PDCA relies on rapid improvement cycles to reach the optimal state.[27,29,32,33] DMAIC, by contrast, emphasizes deliberate analysis prior to making any attempts at improvement.[30,31,34] Each method when applied to handoff models creates opportunities for improvement.

To understand PDCA, think of the do step as a piloted handoff model.[27,29,32,33] The definition of the plan step then follows naturally: before starting a pilot, the team must plan a version of the handoff to be tested. Full consensus on the plan is not necessary[33]: revisions to the original pilot will be rapidly planned, tested, and analyzed through another PDCA cycle until either (1) initial outcomes match desired results, or (2) new outcomes improve upon previous outcomes.[29,32,33]

Next, the team checks if each pilot meets the criteria detailed in steps (1) and (2).[29,32,33] Then, the team acts by standardizing those aspects of the piloted program that definitively pass both criteria. Lastly, the team restarts the cycle with a revised handoff that corrects those aspects that did not meet the criteria. Continue until the handoff meets the two criteria mentioned above.

For example, a new handoff intends to improve the quality of inpatient trips from the general wards to the Catheterization (Cath) Lab. The goals are to improve the completeness of documentation and the efficiency of transfer. Instead of attempting to design a handoff model that immediately corrects every issue, the team can implement PDCA to sequentially address each problem. The team can also design a template to improve documentation by ensuring completeness before the transfer request is sent to the Cath Lab. After this initial pilot, the team notices that although documentation has improved, transfers are now taking longer. The second PDCA cycle should identify the cumbersome components of the handoff, and test a new program which improves efficiency.

While PDCA is effective in certain situations, it has limitations. The frequency of PDCA cycles are limited by the time it takes to develop a revised handoff. If each pilot needs extensive review, practicing PDCA can be inefficient: due to the rapid plan phase, initial pilots underperform and time is wasted waiting to review each subsequent pilot.[27] Further, the success of PDCA is particularly dependent on whether the check phase is meticulously applied.[27,29,33] Simple metrics of success may be misleading and more complicated measurements are often required in such circumstances.

The DMAIC model imposes a rigor of analysis that is not explicit in PDCA.[34,35] In the define phase, the team specifies the components of the current handoff work system, and the scope and goals of the project. The measure phase collects data on whether the current handoff procedure matches the desired goals. One should actively seek to avoid data collection errors such as biased or incomplete samples.

The analyze phase explores the common problems in the handoff model. A multitude of analysis techniques are used in practice; Root Cause Analysis is one such example. The team then uses the analysis results to design a new handoff, ensuring that the new process addresses the most significant issues first. The improve phase then implements that design.

Immediately following implementation, DMAIC requires the team to sustain the improvements by using tools to control or monitor the changes and their effects.[34,35,36] One useful tool is a Control Chart, discussed in our Root Cause section. If the team observes an undesirable effect, they could restart an improvement cycle to address the issue.

Both iterative models establish a paradigm for controlled, sustainable improvement. The PDCA initiates a series of quick cycles to effectively address individual revisions. The DMAIC initiates more deliberate, in depth revisions tested through rigorous measures. Determining the optimal model for a department depends on how the new model will change from the original handoff, and how involved the department will be in extensively monitoring the changes.[27,33]

A “LEAN” PERSPECTIVE

Regardless of the improvement method chosen, the team will identify certain components of the handoff that are prone to error, delay, or redundancy. In general, such issues can be classified as waste: any activity that consumes resources but does not add value to patient care.[37] Lean is a QI methodology devoted to eliminating such waste to achieve sustainable improvement. Lean’s waste-reduction principles originated in manufacturing[1] and it is now popular in many industries, including healthcare.[38,39,40]

Lean principles are rooted in the seven categories of Lean “waste”[37,41]:

- Defects
- Over-processing

- Over-production
- Inventory
- Transportation
- Motion
- Waiting

To illustrate what handoff components would fit in each category, consider the following examples:

Defects include

The defect itself (e.g. During a shift change handoff, a caregiver forgetting to mention that a verbal order was recently given to remove the patient's urinary catheter),

The time and medical supplies spent making the defect (e.g. the time wasted providing the original verbal order)

The remedy for the defect (e.g. the time spent providing the new verbal order, or even the time and medical supplies spent caring for a UTI that results from the excessive catheter use).

Over-processing [37,40,42] is spending too much time on a necessary handoff step, such as double-checking handoff documentation to ensure accuracy. Over-production [37,40,42] is the completion of unnecessary additional handoff steps, such as describing the handoff to a second physician when a discussion with the initial physician should have been adequate. Inventory [37,42] is any extra inputs to the handoff beyond what is absolutely critical, such as documenting the patient's upcoming procedures both in the nursing notes and on the pre-handoff checklist. Transportation [37,42] involves any excess movement of the patient or patient's belonging and information. Wasteful motion [37,41,42,43] involves any activity that does not add value. Most motion is wasteful, but an extreme example is a resident walking to meet with a technician when a phone conversation would suffice. Waiting [37,41,42,43] is measured in time; in this context, it is how long the new staff takes to assume independent care for the patient.

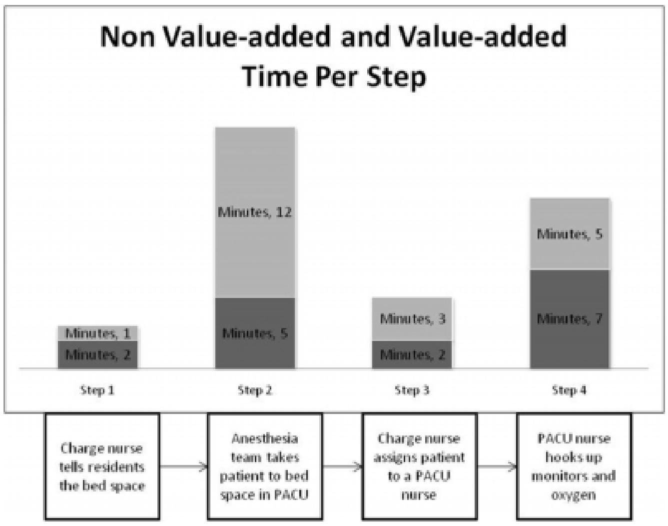
Some forms of waste are impossible to remedy.[42,44] A patient in need of an MRI unavoidably needs to travel to the MRI suite due to the machine's size and expense. In other cases, desirable variation is mistakenly identified as waste. Assuring a new cancer patient multiple, "redundant" times that many treatment options are available for their condition isn't wasteful, it is appropriate bedside manner.

Defining waste is one among the many lessons in Lean philosophy. Lean techniques can also enhance the way a team views a Process Map.[37-46] It is productive to rank each step in the process by the amount of waste and begin addressing the worst. One of the best ways to evaluate waste is to determine the value-added time and effectiveness of each step in the handoff process.[41,42,45,46] Value-added (VA) time is what improves or at least maintains a patient's health state.[41] Examples include the time spent inserting a prosthetic knee for a patient with severe osteoarthritis. Effectiveness is measured by comparing the number of desirable outcomes to the number of outcomes.[41] Administering H1N1 flu vaccination to those who face a higher mortality improves the overall effectiveness of the vaccine. Though all age demographics are susceptible to H1N1 flu, vaccinating high-risk patients first is most effective.

In Figure 2, we demonstrate how one would depict value-added time and effectiveness on a process map; specifically the surgery-to-recovery handoff at a hypothetical academic institution.

Figure 2

Figure 2



Differentiating value-added (VA) time from non-value-added (NAV) time.Here is a simplified four-step process of moving a surgery patient to the PACU. To minimize completion time, the team should first devise improvements to reduce non-value-added (NVA) time (upper values), particularly in step two, instead of focusing on the value-added (VA) time (lower values).

Lean fosters a working environment where continual learning and inquiry thrive. New sources of waste will continue to challenge any process, but Lean initiatives will lead to the resolution of such issues. Such a culture is critical to a successful, sustainable patient handoff.

ROOT CAUSE ANALYSIS

Root cause analysis (RCA) is a problem solving method that identifies undesirable variation in a specific event or process, and uncovers the root causes of those problems.[47] Since a handoff model's success is determined by its ability to handle the variations of clinical care, RCA is a valuable tool for identifying the underlying causes of problematic variation.[47,48,49]

In our context, a QI team starts by documenting a handoff process map. Next, note the inherent fluctuations in each step (e.g. the delays in surgery start time). Once each source of variation is identified, the team separates that variation which is desirable from that which is problematic or unnecessary.[48,50,51] A helpful guide for distinguishing between desirable and problematic variation is our discussion of Lean waste in the previous section.

Next, the team identifies what contributes to the problems. The process proceeds onward until the basic root causes are clearly identified. Some of the underlying factors are broad, systemic issues, and deserve thorough investigation. Others are specific and corrective action is easier to implement.

The team presents RCA results in a variety of ways. We discuss three formats: a Tree Diagram, Pareto Chart, and a Control Chart.[49,51-54]

Often, root problems stem from a few defined sources, so the Tree Diagram is a natural method.[49] It organizes each event individually and branches out to display its causes. A problematic event can have many branches before leading to the root cause.

Alternatively, Pareto Charts are not organized in a cause-and-effect diagram[52]; rather they indicate how often each problematic event occurs. As such, they require data collection to populate.

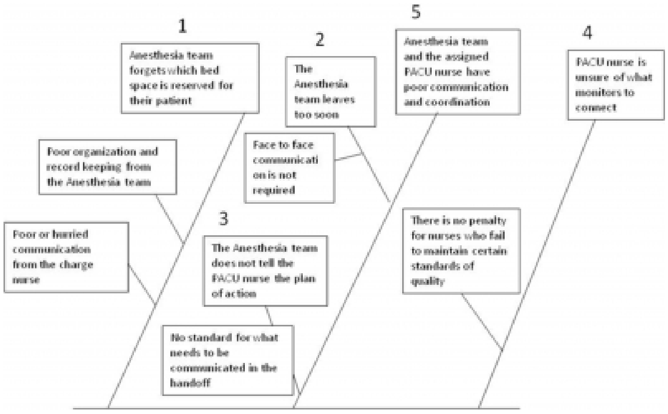
A Control Chart isolates one or more error types in a Pareto Chart and plots performance over time.[30] The chart alerts the team to significant, undesirable trends in a given performance metric.

Used together, the three tools allow one to visualize inefficiencies along the entire handoff process map and then focus on variations at each individual step.

In the Lean section, we reviewed part of a hypothetical handoff process map. Applying RCA to this map starts by interviewing the relevant staff. After the interviews, the team could use a Tree Diagram to visually depict the issues (shown in Figure 3). Notice that each branch displays a sequential series of logic that eventually leads to a root cause.[48] The root causes suggest an intuitive plan for improvement.

Figure 3

Figure 3

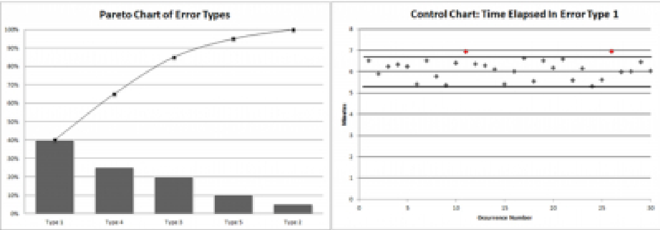


Depicting RCA as a tree diagram.This tree diagram allows one to clearly visualize the relationship of each root cause and the step-by-step approach in elucidating it. One must be clear in defining exactly what constitutes a root cause problem: "poor communication" and similar generalized problems often belie a more specific true root cause which must be teased out.

A Pareto Chart could also help in our example. Assume we institute a survey to assess the frequency of the five root causes. After administering the survey, we obtain the following frequencies: (1), 40%; (2), 25%; (3), 20%; (4), 10%; (5), 5%;. The Pareto Chart inserted (Figure 4, left) demonstrates the frequency of each variation relative to each other.

Figure 4

Figure 4



Understanding problem variation.We create a hypothetical data set which includes the frequency of each of the five problems highlighted in Figure 3. Figure 4.a indicates that Error Type (1) occurs most often. We then plot the delay time related to each occurrence of Error Type 1 in Figure 4.b. The visual depiction of a 95% confidence interval {5.28, 6.72} around the mean delay time of six minutes indicates that two occurrences (the two red diamonds) may have been due to special causes and should be investigated further.

To understand a particular variation source more thoroughly, the team could develop a Control Chart. The chart plots performance over time for a specific step. Abnormal variation is observed outside designated upper and lower “control limits”. Control limits are a function of the data defined by a confidence interval as a function of the mean, variation (standard deviation), and sample size.[36,53] Consider the first (1) problem cited in our Pareto Chart on the left side of Figure 4 that we hypothetically monitored for thirty independent events. The control limit (Figure 4, right) was set about a ninety-five percent (95%) confidence interval with a mean of six minutes and a standard deviation of two minutes.

Used together, the Tree Diagram, Pareto Chart, and Control Chart visualize inefficiencies along the entire handoff process map and then focus on variations at each individual step. A QI team can study improvement on a more complex level, effectively specifying where the improvements are needed and how well the improvements work. Each model complements one another to organically synthesize a complete understanding of the handoff improvement.

QUANTITATIVE PRIORITIZATION

Implementing a quantitative method to complement PDCA and DMAIC assists in prioritizing the department’s values and the desired goals of the handoff initiative.[54]

Quantitative Prioritization specifies the scope of improvement and organizes the values within a department.[54,55] In the handoff model, these are the aspects that improve the new design (e.g. staff-to-staff communication, patient education, regulatory compliance). This model prioritizes each dimension based on a number ranking that represents the appropriate importance level.[55] Orthogonal to the handoff dimensions are the department’s, or stakeholder’s, values. Such values can be solicited with a variety of methods, including surveys. The goals of the department are similarly determined and given an importance score. By conducting this exercise, the team aligns the department’s values with the dimensions of the handoff to find the best balance.[56,57]

Figure 5 gives an example of the end result. The inner square represents the strength of correlation between any two items. For example, a nine was assigned to the cell where “reduce errors” and “extended personal communication” intersect. Assigning a value of nine implies that stakeholders believe that the two components are strongly correlated. By applying numerical values, we can quantify the aggregate correlations. Note that the 9, 6, or 3 valuation is arbitrary; it simply assesses the relative strength of correlation in this example.[54,55] Each stakeholder has unique values and each team member assesses a handoff dimension’s importance differently. It is left to the team to use a sub-method such as the survey to properly assess the overall strength of correlation.

Lastly, the team adds across each row and column to determine the sum total of each correlation. We then multiply the sum with the preference ranking to obtain a total score.[54,55] Items prioritized as “one” would be multiplied by a factor of “three”, just as items prioritized as “three” would be multiplied by a factor of “one.” The total score helps the QI team determine what to emphasize in merging the handoff dimensions with the department values.

Quantitative Prioritization allows comprehensive, collaborative input from all stakeholders in a value weighted manner. Such collaboration can motivate members within a department to help implement the handoff and help ameliorate potential conflicts that arise during implementation.

Figure 5

Figure 5

Department Values	Handoff Dimensions:	Increase Face to Face Communication	Define Caregiver's Plan of Action	Maintain ACGME Standards	Sum	Importance/Ranking	Total Score
	Reduce Errors In Communication that Lead to Redundant Meetings	9	3	9	21	2	42
	Formalize Clinical Learning	6	9	3	18	1	54
	Provide Quality Care and Emphasize Quality Improvement	6	9	3	18	3	18
	Sum	21	21	15			
	Importance/Ranking	3	2	1			
	Total Score	21	42	45			

Constructing a Prioritization Matrix.The numbers, 3, 6, and 9, in the center large box represent the estimated strength of correlation between a given row and column. The Importance Rankings are established independently of the correlations. High rank implies high importance.

CONCLUSION

Medical programs must develop innovative methods to incorporate the trends in medical handoffs into their curricula. Knowledge brokering key concepts from other disciplines elucidates opportunities to improve the handoff transition and to educate why such improvements are necessary. Medicine must integrate new disciplines, such as Industrial Engineering QI, to best prepare residents for medical practice because these methods discordantly reflect how one perceives handoff transitions. And this perspective provides a different latitude that is both implementable and educational.

These QI principles represent an overview of the analyses necessary to overcome common impediments to successfully implementing handoff quality improvement. These models are among the many one can utilize to study handoff improvements; and a focus on why these principles lead to success is more important than rote memorization of these principles. We provide unique insight from these models to best understand how one can apply each model in a specific context. We arranged each model in the order that they are likely to be useful to a QI team innovating a new handoff model.

A medical department seeking to educate its residents on handoff improvements should structure the training along this framework. Presenting handoffs as a complex field ripe with principles from many disciplines allows the residents to appreciate the complexity in handoffs and to systematically learn the improvement methods. These models, when combined, integrate into a framework conducive for resident learning.

APPENDIX

Each model is described in brief with suggestions for when it can be most efficiently implemented in the handoff process.

Figure 6

Table 1

	Purpose	Role In Handoff Quality Improvement	Questions Each Method Addresses
7-S	Captures how certain parameters, once changed, affect the entire work system Helps anticipate resistence to change and plan for requisite efforts	Depicts how each change affects the entire handoff work system Moderates diagreement about the components of the new handoff	Do I know all consequences of the new handoff? What changes will be most contentious?
PDCA	Provides a structure for rapid continuous improvement Initiates a change that is then evaluated for effectiveness	Allows a team to try alternative handoff models with quick iterations Emphasizes testing a new handoff before standardizing the change	What steps should I follow to introduce a new handoff? How do I test alternative hand-off designs?
DMAIC	Provides a structure for an effective, large-scale change Includes a thorough analysis of change outcomes	Guides the planning, implementation, and evaluation of a broad, complex handoff change Suggests specific statistical tools to measure the handoff improvement	Am I implementing and executing effective improvement changes? How can I measure the level of improvement?
Lean	Fosters an improvement-based culture that continually reduces system waste Distinguishes activities as either value-added or non-value-added	Helps develop an efficient handoff work system Identifies handoff components which do not add value	Does our handoff fit in our culture of continuous improvement and error reduction? How can I save time and simultaneously prevent handoff errors?
RCA	Identifies underlying factors causing errors Prompts exploring the frequency and variation of various problems	Helps understand how specific issues cause handoff errors Applies qualitative and quantitative analysis to handoff problems	How do I determine the real causes of this problem? How do I know a problem is important?
Prioritization Matrix	Aligns overall values with the change initiative Determines what to emphasize when designing a change	Connects overall values and preferences to the handoff improvement process Empowers all teammembers to influence the new handoff design	How do our values and preferences relate to this handoff improvement? How can our QI team resolve disagreements over handoff design?

The following articles have more information on each topic:
7-S Framework: (3,5,6). PDCA: (1,3,6,7). DMAIC (6,8). Lean (1-5). RCA (6,7,8,9). Prioritization Matrix (2,3).

Summarizing each method.These principles represent an overview of common impediments to successfully implementing handoff quality improvement. These methods are among the many one can utilize to improve medical handoffs; a focus on why these principles lead to success is more important than the choice of methods.

ACKNOWLEDGEMENTS

We would like to acknowledge Dr. Vineet Arora of the University Of Chicago Pritzer School Of Medicine and Dr. David Mayer of the University of Illinois, Chicago for their educational guidance and support during the drafting of this manuscript.

References

1. Friesen LD, Vidyarthi AR, Baron RB, Katz PP: Factors associated with intern fatigue. J Gen Intern Med; 2008; Dec;23(12):1981-6.
2. Rosen IM, Gimotty PA, Shea JA, Bellini LM: Evolution of sleep quantity, sleep deprivation, mood disturbances, empathy, and burnout among interns. Acad Med; 2006; Jan;81(1):82-5.
3. Gopal R, Glasheen JJ, Miyoshi TJ, Prochazka AV: Burnout and internal medicine resident work-hour restrictions. Arch Intern Med; 2005; Dec 12-26;165(22):2595-600.

4. Dawson D, Zee P: Work hours and reducing fatigue-related risk: good research vs good policy. JAMA; 2005; Sep 7;294(9):1104-6.
5. Papp KK, Stoller EP, Sage P, Aikens JE, Owens J, Avidan A, Phillips B, Rosen R, Strohl KP: The effects of sleep loss and fatigue on resident-physicians: a multi-institutional, mixed-method study. Acad Med; 2004; May;79(5):394-406.
6. Weinstein DF: Duty hours for resident physicians--tough choices for teaching hospitals: N Engl J Med; 2002; Oct 17;347(16):1275-8.
7. Mazotti LA, Vidyarthi AR, Wachter RM, Auerbach AD, Katz PP: Impact of duty-hour restriction on resident inpatient teaching. J Hosp Med; 2009; Oct;4(8):476-80.
8. Nuckols TK, Escarce JJ: Residency work-hours reform. A cost analysis including preventable adverse events. J Gen Intern Med; 2005; Oct;20(10):873-8.
9. Fletcher KE, Underwood W 3rd, Davis SQ, Mangrulkar RS, McMahon LF Jr, Saint S: Effects of work hour reduction on residents' lives: a systematic review. JAMA; 2005; Sep 7;294(9):1088-100.
10. Nakayama DK, Thompson WM, Wynne JL, Dalton ML, Bozeman AT, Innes BJ: The effect of ACGME duty hour restrictions on operative continuity of care. Am Surg; 2009; Dec;75(12):1234-7.
11. Myers, Jennifer S. MD; Bellini, Lisa M. MD; Morris, Jon B. MD; Graham, Debra MD; Katz, Joel MD; Potts, John R. MD; Weiner, Charles MD; Volpp, Kevin G. MD, PhD: Internal Medicine and General Surgery Residents' Attitudes about the ACGME Duty Hours Regulations: A Multicenter Study. Academic Medicine; 2006; Volume 81 Issue 12: 1052-1058 doi: 10.1097/01.ACM.0000246687.03462.59
12. "Common Program Requirements." ACGME | Accreditation Council for Graduate Medical Education; 2010; Web. 01 Oct. 2010. http://www.acgme.org/acWebsite/dutyHours/dh_index.asp
13. Wayne JD, Tyagi R, Reinhardt G, Rooney D, Makoul G, Chopra S, Darosa DA: Simple standardised patient handoff system that increases accuracy and completeness. J Surg Educ; 2008; Nov-Dec;65(6):476-85.
14. Committee on Patient Safety and Quality Improvement: ACOG committee opinion. Number 367. June 2007. Communication strategies for patient handoffs. Obstet Gynecol; 2007; Jun;109(6):1503-5
15. Welsh CA, Flanagan ME, Ebright P: Barriers and facilitators to nursing handoffs: Recommendations for redesign. Nurs Outlook; 2010; May-Jun;58(3):148-54.
16. Arora V, Johnson J: A model for building a standardised hand-off protocol. Jt Comm J Qual Patient Saf; 2006; Nov;32(11):646-55.
17. Borowitz SM, Waggoner-Fountain LA, Bass EJ, Sledd RM: Adequacy of information transferred at resident sign-out (in-hospital handover of care): a prospective survey. Qual Saf Health Care; 2008; Feb;17(1):6-10.
18. Horwitz LI, Moin T, Krumholz HM, Wang L, Bradley EH: Consequences of inadequate sign-out for patient care. Arch Intern Med; 2008; Sep 8;168(16):1755-60.
19. Patterson ES: Structuring flexibility: the potential good, bad and ugly in standardisation of handovers. Qual Saf Health Care; 2008; Feb;17(1):4-5.
20. Gawande, Atul: The Checklist Manifesto: How to Get Things Right. Metropolitan Books; 2009.
21. Waterman, R. Jr., Peters, T. and Phillips, J.R.: "Structure Is Not Organisation" in Business Horizons, Vol. 23(3), pp.14–26; 1980;
22. Peters, T. and Waterman, R: "In Search of Excellence", New York, London: Harper & Row; 1982;
23. Pascale, R: Managing on the Edge: How Successful Companies Use Conflict to Stay Ahead. Simon and Schuster. New York; 1990;
24. Rasiel M, Friga P: The McKinsey Mind: Understanding and Implementing the Problem Solving Tools and Management Techniques. McGraw-Hill; 2001;
25. Grandori, Prencipe: Organizational Invariants and Organizational Change. European Management Review; 2008; 232-244
26. Gonzalez, J: Diversity Change in Organizations: A Systemic, Multilevel, and Nonlinear Process. The Journal of Applied Behavioral Science; 2010; Retrieved July 2010 from ABI/INFORM Complete. (Document ID: 2079910231).
27. Berwick: “Developing and Testing Changes in Delivery of Care”. Annals of Internal Medicine; 1998; 128(8) pp 651-656
28. Kumar S: Thomas KM. Utilizing DMAIC six sigma and evidence-based medicine to streamline diagnosis in chest pain. Qual Manag Health Care; 2010; Apr-Jun;19(2):107-16.
29. Chen, TK, Su CH, Su CT: Implementation of a Customer Satisfaction Program: a Case Study. Industrial Management & Data Systems; 2002; 102(5) pp 252-259.
30. EI Bluth, M Havrilla and C Blakeman: Quality improvement techniques: value to improve the timeliness of preoperative chest radiographic reports. American Journal of Roentgenology; 1993; Vol 160, 995-998
31. DuPree E, Martin L, Anderson R, Kathuria N, Reich D, Porter C, Chassin MR: Improving patient satisfaction with pain management using Six Sigma tools. Jt Comm J Qual Patient Saf; 2009; Jul;35(7):343-50.
32. Peer KS, Rakich JS: Accreditation and Continuous Quality Improvement In Athletic Training Education. Journal of Athletic Training; 2000; 35(2):188-193.
33. Coffey, RM, Matthews, TL, McDermott, K: Diabetes Care Quality Improvement: A Resource Guide for State Action (Module 5: Improvement - Developing a Strategy for Diabetes Quality Improvement). Agency for Healthcare Research and Quality; 2004; Publication No. 04-0072. pp 85-96.
34. Dreachslin JL, Lee PD: Applying Six Sigma and DMAIC to diversity initiatives. J Healthc Manag; 2007; Nov-Dec;52(6):361-7.
35. NIST/SEMATECH e-Handbook of Statistical Methods. Section 6.3: Univariate and Multivariate Control Charts. URL: http://www.itl.nist.gov/div898/handbook/pmc/section3/pmc3.htm. Accessed July 15th, 2010.
36. Roberts SW: Control Chart Tests Based on Geometric Moving Averages. Technometrics; 2000; 42(1) pp. 97-101. Originally published in 1959 by American Statistical Association and Americian Society for Quality.
37. Shingo, Shigeo: A study of the Toyota Production System. Productivity Press; 1989; p 47.
38. Black, John: The Toyota Way to Healthcare Excellence: Increase Efficiency and Improve Quality with Lean. Health Administration Press; 2008;
39. Graban, Mark: Lean Hospitals: Improving Quality, Patient Safety, and Employee Satisfaction. Productivity Press; 2008;
40. Chalice, Robert: Improving Healthcare Using Toyota Lean Production Methods: 46 Steps for Improvement. ASQ Quality Press; 2007; Second Edition
41. Rother, Mike and Shook, John: Learning to See: Value Stream Mapping to Add Value and Eliminate MUDA. Productivity Press; 1999;
42. Hadfield, Debra and Holmes, Shelagh: The Lean Healthcare Pocket Guide. MCS Media, Inc.; 2006;
43. Womack, JP, Jones, DT: Lean thinking: banish waste and create wealth in your corporation. Free Press; 2003;

44. DelliFraine JL, Langabeer JR 2nd, Nembhard IM: Assessing the evidence of six sigma and lean in the health care industry. Qual Manag Health Care; 2010; Jul-Sep;19(3):211-25.
45. Buell JM: Lean Six Sigma and patient safety: a recipe for success. Healthc Exec.; 2010; Mar-Apr;25(2):26-8, 30, 32 passim.
46. Deckard GJ, Borkowski N, Diaz D, Sanchez C, Boisette SA: Improving timeliness and efficiency in the referral process for safety net providers: application of the Lean Six Sigma methodology. J Ambul Care Manage; 2010; Apr-Jun;33(2):124-30.
47. Marcel van Assen, Gerben van den Berg, Paul Pietersma: Key Management Models. Prentice Hall. Financial Times; 2003;
48. Rooney, Vanden Heuvel: Root Cause Analysis For Beginners. Quality Basics. Quality Progress; 2004;
49. Wu, Lipshutz, Pronovost: Effectiveness and Efficiency of Root Cause Analysis in Medicine. JAMA; 2008; 299(6):685-687.
50. Levitan, D: Digital Handoff Smoothes Flow Between OR and ICU. Anesthesiology News; June; http://www.anesthesiologynews.com/index.asp?section_id=8&show=dept&ses=ogst&issue_id=637&article_id=15241. Accessed: June 23, 2010
51. A Brief History of Root Cause Analysis. Root Cause Analysis in Developmental Disabilities. UMass Medical School. http://www.cherylgray.com/RCA/history.html. Accessed: July 9th, 2010.
52. Pareto Charts. Distribution and Causal Analysis Tools. http://www.hanford.gov/rl/uploadfiles/vpp_pareto.pdf. Accessed: August 13th, 2010
53. NIST/SEMATECH e-Handbook of Statistical Methods. Section 6.3: Univariate and Multivariate Control Charts. URL: http://www.itl.nist.gov/div898/handbook/pmc/section3/pmc3.htm. Accessed July 15th, 2010.
54. Tapke J, Muller A, Johnson G, Sieck J: House of Quality: Steps to Understanding the House of Quality.
55. H. Wang; M. Xie, T. N. Goh: A comparative study of the prioritization matrix method and the analytic hierarchy process technique in quality function deployment. Total Quality Management & Business Excellence; http://dx.doi.org/10.1080/0954412988361. Accessed: August 10th, 2010.
56. Marken, R: A Model-Based Approach to Prioritizing Medical Safety Practices. Advances in Patient Safety: From Research to Implementation; Volume 2. National Library of Medicine.
57. Khan S: A Model for Metrics-Driven Feature Prioritization. Pragmatic Marketing; 2005; Volume 3. Issue 3. May/June. http://www.pragmaticmarketing.com/publications/magazine/3/3/vol3iss3.pdf. Accessed: July 25th, 2010.
58. Hauser J, Clausing D: The house of quality. Harvard Business Review; 1988; May-June, 63-73
59. Croteau R: JCAHO comments on handoff requirement. OR Manager; 2005; Aug;21(8):8.
60. Wayne JD, Tyagi R, Reinhardt G, Rooney D, Makoul G, Chopra S, Darosa DA: Simple standardised patient handoff system that increases accuracy and completeness. J Surg Educ; 2008; Nov-Dec;65(6):476-85.
61. Mascioli S, Laskowski-Jones L, Urban S, Moran S: Improving handoff communication. Nursing; 2009; Feb;39(2):52-5.
62. Burns, Tom. GM Stalker: The management of innovation. Palgrave Macmillan; 1961;
63. Swing, S. R.: Assessing the ACGME General Competencies: General Considerations and Assessment Methods. Academic Emergency Medicine; 2002; 9: 1278–1288. doi: 10.1197/aemj.9.11.1278

Author Information

Jay K. Joshi, M.D., M.B.A
Booth School of Business, University of Chicago

Thomas J. Best, M.S.
Booth School of Business, University of Chicago