Appendix F: Tool Compendium

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
5S	Martin K. 5S: A powerful tool for creating high-performing healthcare organizations. 2007 Society for Health Systems Conference; 2007; New Orleans, LA; 2007. Woodward H, Suskovich D, Workman-Germann J, et al. Adaptation of lean methodologies for healthcare applications. 2007 Society for Health Systems Conference; 2007; New Orleans, LA; 2007. Woodcock E. The lean-thinking revolution. Mastering patient flow: using lean thinking to improve your practice operations. 3rd ed. Englewood: Medical Group Management Association; 2009. p. 11-40. Tague N. The tools. In: O'Mara P, editor. The quality toolbox. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2005. p. 93-521.	A simple and powerful performance improvement tool that stands for the five steps to creating workplace organization: Sort, Straighten, Scrub, Standardize, and Sustain. Commonly misinterpreted as simply housekeeping, the implementation of 5S provides benefits that are far more than merely a neat and clean organization. When fully implemented, 5S eliminates the need to search for items, reduces the probability of errors, increases productivity, improves quality, ensures quicker response time, improves morale, and modifies the appearance of the department to convey a more professional image. A simple and powerful performance improvement tool that stands for the five steps to creating workplace organization: sort, set in order, shine, standardize and sustain. Focuses on creating and maintaining an organized and clean environment. Commonly misinterpreted as simply housekeeping, the implementation of 5S	1. **Sort**: clear the area, reduce clutter and keep only essential items 2. **Straighten**: create designated locations, label everything 3.**Scrub**: create a clean and neat workplace 4. **Standardize**: maintain the organized workplace 5. **Sustain**: Ingrain 5S into workplace culture Expertise: 1 Resources: cleaning supplies	Pros: • Simplifies work • Creates safer workplace • Reduces workforce frustration • Increases productivity • Builds pride in workplace • Builds customer confidence • Reduces exposure to risk • Reduces costs • Easier to train new staff • Makes problems visual • Instills organizational discipline Cons: • Can be time consuming	

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		provides benefits that are far more than merely a neat and clean organization. In English, the five phases of implementation are Sort, Straighten, Scrub, Standardize, and Sustain. When fully implemented, 5S eliminates the need to search for items, reduces the probability of errors, increases productivity, improves quality, ensures quicker response time, improves morale, and modifies the appearance of the department to convey a more professional image. Used: • When an organization or part of an organization is disorganized and/or unclean			

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5W2H (Also called: 5W2H method, 5W2H approach)	Tague N. The tools. In: O'Mara P, editor. The quality toolbox. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2005. p. 93-521. Mycoted. Creativity and innovation techniques. 2009. Available at: http://www.mycoted.com/Category:Creativity_Techniques. Accessed August 24, 2009.	5W2H is a method for asking questions about a process or problem. Its structure forces you to consider all aspects of the situation. The five Ws are who, what, when, where, and why. The two Hs are how and how much (or many). Used: • When analyzing a process for improvement opportunities • When a problem has been suspected or identified but must be better defined • When planning a project or steps of a project (such as data collection or rolling out changes) • When writing an article, report, or presentation	1. **Review the situation under study**. Make sure everyone understands the subject of the 5W2H. 2. **Develop appropriate questions about the situation** for each of the question words (who, what when, where, why, how, how much). The order of asking questions is not important. 3. **Answer each question**. If answers are not known, create a plan for finding them. 4. What you do next depends on your situation: If you are planning a project, let your questions and answers help form your plan If you are analyzing a process for improvement opportunities, let your question and answers lead you into additional questions about possible changes If you are defining a problem, let your questions and answers lead you into cause analysis If you are reviewing a completed project, let your questions and answers lead you into additional questions		

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			about modifying, expanding, or standardizing your changes If you are preparing an article, report, or presentation, include answers to the questions in your text Expertise: 1 Resources: none		

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Affinity Diagrams (Also called: affinity chart, K-J method)	The Hiser Group. Observe and analyse–Toolkit. 2006. Available at: http://www.hiser.com.au/the_hiser_element_toolkit/observe_and_analyse_-_toolkit.html. Accessed May 20, 2009. American Society for Quality. Idea creation tools: affinity diagram. 2009. Available at: http://www.asq.org/learn-about-quality/idea-creation-tools/overview/affinity.html. Accessed June 22, 2009. McCray M. How to get paid for the services you provide. 2007 Society for Health Systems Conference; 2007; New Orleans, LA; 2007. George M, Rowlands D, Price M, et al. Working with ideas. The lean six sigma pocket toolbook. New York: McGraw–Hill; 2005. p. 27-32. Tague N. The tools. In: O'Mara P, editor. The quality toolbox. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2005. p. 93-521. Bauer J, Duffy G, Westcott R, editors. The quality improvement handbook, Improvement Tools. 2nd ed.	An affinity diagram helps to synthesize large amounts of data by finding relationships between ideas. It organizes facts, opinions and issues into natural groups to help diagnose a complex situation and find themes. Affinity diagramming is an analysis tool used to make sense of the unstructured information captured during field studies, usability analysis or evaluation activities through a 'bottom up' group interpretative process. Affinity diagramming uses inductive thinking to organize large amounts of qualitative data into high-level conceptual groups ('affinities') to reveal underlying issues and structure. These in turn reveal usability implications for an application's design. Tool that gathers large amounts of language data (ideas, opinions, issues) and organizes them into groupings based on their natural relationships. Used when need to sift through large volumes of data and/or to encourage new patterns of thinking. The affinity diagram organizes a large number of ideas into their natural relationships. This method taps a team's creativity and intuition. Affinity Diagrams are used to	1. After brainstorming, write all ideas on separate note cards or sticky notes. Spread all out on work surface. 2. Group together related ideas. 3. Discuss shape of diagram, patterns, etc. Label all groups. 4. Combine groups into "supergroups" if appropriate. 1. Gather ideas from brainstorming session, or customer need statements from interview transcripts, surveys, etc. 2. Write ideas on cards or sticky notes. 3. Post sticky notes randomly on a board or flip chart, or on a table if using note cards. 4. Allow people to silently start grouping the cards or notes. 5. When the clustering is done, create a "header" label for each group. 6. Do a second round of clustering if desired. 7. Complete the diagram and discuss the results. 1**. Identify the problem.** Write the problem or issue on a blackboard or flip chart. Note: If ideas or data have already been generated, skip to step 3.	Pros: • Groups ideas in a manner that allows those with a natural relationship or relevance to be placed together in the same group or category • Promotes creativity • Flexible in terms of user and situation Cons: • Can be time consuming • Should have at least 15 items of information identified	

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Allocation of Function Analysis	Stanton N, Salmon P, Walker G, et al. Design methods. Human factors methods: a practical guide for engineering and design. Great Britain: Ashgate; 2005. p. 483-504.	Allocation of function analysis is used during the design process in order to allocate jobs, tasks, functions and responsibility to the man or machine for the system in question. Allocation of function involves the design team considering each task and the relative advantages and disadvantages associated with that task being performed by the man, or by the machine. Allocation of functions analysis is particularly important when considering system automation. Used: • To allocate jobs, tasks, functions and responsibility to the man or machine for a system	1. **Define the task(s) under analysis**. The first step in an allocation of function analysis is to define the task(s) to be considered during the analysis. It is recommended that an exhaustive set of tasks for the system under analysis are considered. However, it may be that a number of the tasks are already allocated to either the man or machine and so only those tasks that require functional allocation should be considered. 2. **Conduct a HTA for the task(s) under analysis**. Once the tasks under analysis are defined, a hierarchal task analysis (HTA) should be conducted for each task or scenario. HTA involves breaking down the task under analysis into a hierarchy of goals, operations and plans. Tasks are broken down into a hierarchical set of tasks, sub-tasks and plans. It is recommended that each bottom level task step in the HTA is considered during the allocation of functions analysis. 3. **Conduct stakeholder analysis for allocation of**	Pros: • Allocation of functions analysis is a simplistic procedure that allows tasks to be allocated appropriately within the system or deice under analysis • Analysis of functions allows the designers to ensure that the tasks are carried out by the most efficient system component • Allocation of functions analysis provides a structure to the automation decision process and also ensures that automation decisions are traceable • Provided that the appropriate personnel are used, the procedure is a simple and straightforward one Cons: • The procedure can be laborious and time consuming, particularly for complex systems or devices • A multi-disciplinarily team of HF specialists, potential end users, and designers are required in order to conduct the analysis properly. It may be difficult to assemble such a team.	

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			functions. A stakeholder analysis is conducted in order to identify stakeholder satisfaction and dissatisfaction caused by changes in the computer systems in the system or type of system under analysis. Observational study is required in order to conduct the stakeholder analysis. The stakeholder analysis involves determining the current knowledge and skills of the existing stakeholders and the potential of stakeholders to develop new knowledge and skills. The analyst should also consider a number of aspects of work that are important to the stakeholders involved, such as the development of new skills, enjoying interaction with other people and having a variety of work to do. 4. **Consider human and computer capabilities**. Next, the analyst(s) should consider each bottom level task step in the HTA and the associated advantages and disadvantages of allocating that task to		

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			the human operator or to the machine or system. The capability of the personnel and the technological artifacts involved should be considered with respect to each task step in the HTA. Each task step should be allocated to human only (H), the human and computer with the human in control (H-C), the human and computer with the computer in control (C-H), or the computer only (C). 5. **Assess impact of allocation of function on task performance and job satisfaction**. Once the tasks have been allocated, the analyst(s) should review each allocation and determine the effects upon task performance and job satisfaction. The analysts should consider error potential, performance time gains/losses, impact upon cost, mental workload and the job satisfaction criteria highlighted earlier in the analysis. For any allocations that have a significant negative effect upon task performance and job satisfaction, the		

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			analyst(s) should determine an alternative allocation of function. The alternative allocation of functions for the task step in question should then be compared, and the most suitable allocation selected. Expertise: 2 Resources: none		

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AΔT	Andersen B. Tools for implementing improvements. In: O'Mara P, editor. Business process improvement toolbox. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2007. p. 237-49.	The main purpose of AΔT analysis is to set ambitious targets for the improvement work. The method is based on the assumption that it is always possible to find two durations accumulated costs, total number of defects, or other performance measure for a given process: • "A" stands for actual: the actual time, costs, and so forth, currently related to performing the process to be improved • "T" stands for theoretical: the theoretically fastest time, lowest cost, and so forth, that can be achieved when performing the process • The ratio is calculated between the A and T values: Δ = A/T. This ratio expresses the improvement potential in eliminating all unnecessary activities and performing the process as efficiently as possible. The higher the ratio, the higher the potential. This ratio can also be used as an expression of how much there is to gain by approaching the ideal process. Used: • To set ambitious targets for the improvement work • With benchmarking	1. Start the analysis from the flowchart for the current process. 2. In the flowchart, **add figures** for time, cost, number of defects, and so on, for each activity. 3. **Critically evaluate each activity** to determine whether it adds value. If it does not, determine whether it can be eliminated. Activities that can be eliminated are marked with a color or by some other suitable means. 4. **Summarize the A values and the T values**, where the T values are all the non-marked activities, and calculate the ratio A/T. 5. **Set the improvement target** at or close to the T value. Expertise: 2 Resources: flowchart, numerical data of accumulated performance measures for the process		

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Balanced Scorecard	Tague N. The tools. In: O'Mara P, editor. The quality toolbox. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2005. p. 93-521. Tidd J, Bessant J, Pavitt K. SWOT analysis. 2001. Available at: http://www.wiley.co.uk/wileychi/innovate/website/pages/atoz/swot.htm. Accessed August 24, 2009.	The balanced scorecard suggests that we view the organization from four perspectives, and to develop metrics, collect data and analyze it relative to each of these perspectives: The Learning and Growth Perspective The Business Process Perspective The Customer Perspective The Financial Perspective. Within each perspective, measures chosen by the organization reflect its business strategy. At every level of the organization, measures, targets, and actions are chosen that support the overall organization scorecard. Thus, the balanced scorecard allows everyone to plan for and monitor improvement on the issues most important to the organization's success. The balanced scorecard is a set of measures that gives a quick overall view of the performance of an organization or business unit. Measures are grouped into four perspectives: customer, internal business, innovation and learning, and financial. Within each perspective, measures chosen by the organization reflect its business strategy. At every level of the organization, measures, targets, and actions are chosen that support the overall organization	1. Reach a consensus on the vision and strategy of the organization. 2. **Consider what each of these four perspectives means** for the organization: customer, internal business, innovation and learning, financial. Decide whether the names should be changed to make the perspectives more meaningful for the organization, or even if a perspective should be added. 3. For each perspective, **choose no more than five measures** that would indicate progress toward achieving the organization's strategy. 4. **Choose ambitious targets** for each measure that, when achieved, will bring the organization closer to its vision of excellence. Expertise: 1 Resources: none	Pros: • Prevents an organization from creating improvements in one area that hurt the organization in another • Helps a group think about which of several ways of accomplishing a goal would be best for the organization overall • A powerful tool for focusing strategy	

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Benchmarking	Cowan D. Benchmarking—Leading managers to find and implement better practices. 2007 Society for Health Systems Conference; 2007; New Orleans, LA; 2007. American Society for Quality. Organization-wide approaches: Benchmarking. 2009. Available at: http://www.asq.org/learn-about-quality/benchmarking/overview/overview.html. Accessed June 23, 2009. Yanko S, Gomez E. Tools, techniques, and best practices in the emergency room. 2007 Society for Health Systems Conference; 2007; New Orleans, LA; 2007. Woodcock E. The lean-thinking revolution. Mastering patient flow: using lean thinking to improve your practice operations. . 3rd ed. Englewood: Medical Group Management Association; 2009. p. 11-40. Medical Group Management Association. MGMA	Benchmarking is a structured process for comparing your organization's work practices to the best similar practices you can identify in other organizations (related and unrelated; e.g. health care and manufacturing) and then incorporating these best ideas into your own processes. Benchmarking is a continuous process and should not be considered a one-time event. It is ongoing and should be incorporated into day-to-day work and integrated into the way you think about work, the way you solve problems and the way you learn. Benchmarking is the search for best practices, the ones that will lead to superior performance. Establishing operating targets based on the best possible industry practices is a critical component in the success of every organization. Benchmarking is a technique for learning from others' successes in an area where the team is trying to make improvements. The practice of being humble enough to admit that	1. **Identify what is to be benchmarked**. Be specific in deciding what the team wants to benchmark. 2. **Decide which organizations/functions to benchmark**. The comparison should be conducted not only against peers but also against recognized leading organizations with similar functions (e.g. admissions to a hospital and hotel). 3. **Determine the data collection method and collect data**. Keep the data collection process simple. There is no right way to benchmark. It is important to look outward, be innovative, and search for new and different ways to improve the process under study. 4. **Contact a peer in the benchmark organization**. Explain the purpose of the benchmarking study and what information is desired. Give assurance that confidential information will not be requested. Inquire about the peer's organization: what they do, why they do it, how they measure and/or evaluate it and what their performance	Pros: • Exposes new approaches/solutions to problems • Not difficult • Can create huge leaps in performance • Establishes goals that are ambitious yet realistic • Helps the organization understand and develop a critical attitude toward its business processes • Encourages an open attitude toward seeking and sharing information and thereby is an active learning process that motivates change and improvement in the organization • The organization can find new sources of improvement and new ways of doing things outside its own environment • Reference points are established for performance measurement of business processes Cons: • Long-term commitment • Requires a sufficient amount of process learning, project planning, and staff support • Competitor information may not be publicly available • Benchmark may not be a good benchmark (contains lots of waste, variability, etc.) • Can require significant investments of manpower and time • Too broad a scope dooms	Centers for Medicare & Medicaid Services. Physicians groups continue to improve quality and generate savings under medicare physician pay for performance demonstration. 2008. Available at: http://www.cms.hhs.gov/DemoProjectsEvalRpts/downloads/PGP_Fact_Sheet.pdf Accessed May 20, 2009. Beam J, Rhodes S. Survivor—ED island. 2007 Society for Health Systems Conference; 2007; New Orleans, LA; 2007.

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	practice dashboards. 2009. Available at: http://www.mgmadashboards.com/default.aspx. Accessed July 10, 2009. University Research Co. LLC. Quality Assurance Project: Benchmarking. 2008. Available at: http://www.qaproject.org/methods/resclientwindow.html#benchmarking. Accessed July 28, 2009. George M, Rowlands D, Price M, et al. Selecting and testing solutions. The lean six sigma pocket toolbook. New York: McGraw–Hill; 2005. p. 253-76. Tague N. Mega-tools: Quality management systems. In: O'Mara P, editor. The quality toolbox. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2005. p. 13-34. Bauer J, Duffy G, Westcott R, editors. The quality improvement handbook, Improvement Tools. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2006. p. 109-48. Andersen B. Tools for creating improvements.	someone else is better at something and being wise enough to try to learn how to surpass them at it. Benchmarking is comparing your practice's performance to the performance of other practices. It facilitates the understanding of physician performance and how your practice's costs compare to similar practices. It relies on measurement, comparison and metrics to facilitate management. Because benchmarking measures performance at different times, it's an important tool for observing changes in the practice or physician activity. Benchmarking is: • Continuous search for a better way of doing things • Continuous process to improve productivity, operations, patient flow, quality, or cost • Learning/discovery/improvement process • Adaptive • A planning process • Collaborative • Others' cost are 10% lower, what do they do differently *Benchmarking* is a systematic approach for gathering information about process or product	measures are, what has worked well, and what has not been successful. 5. **Determine whether what the team has learned from benchmarking can be applied** to improve the organization's process. Are there new and different ways to solve the problem or improve the process? Are there other solutions to the problem that the team has overlooked? It's important to keep an open mind about new and perhaps radically different ways of doing things. Accurately assess your strengths and weaknesses. Understand, and compare yourself to, the best practices in the industry and/or its leaders. Learn from industry leaders and your competition. Reveal how and why they are strong in a given area. Do not hesitate to copy or modify and incorporate them in your own operation. Emulate their strengths. Identify other groups,	the project to failure • Inadequate resources can doom a benchmarking study	

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	In: O'Mara P, editor. Business process improvement toolbox. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2007. p. 167-236. Tidd J, Bessant J, Pavitt K. Innovation management toolbox. 2001. Available at: http://www.wiley.co.uk/wileychi/innovate/website/pages/atoz/atoz.htm. Accessed August 24, 2009.	performance and then analyzing why and how performance differs between business units. In other words, benchmarking is a technique for learning from others' successes in an area where the team is trying to make improvements. Benchmarks are measures (of quality, time, cost, etc.) that have already been achieved by some company, somewhere. They tell you what's possible so you can set goals for your own operations. Benchmarking can be very helpful to inject new ideas into the process and borrow the good ideas from other companies/industries. Benchmarking is a structured process for comparing your organization's work practices to the best similar practices you can identify in other organizations and then incorporating these best ideas into your own processes. Benchmarking is an evaluation technique in which an organization compares its own performance for a specific process with the "best practice" performance of a recognized leader in a	organizations, or health facilities that serve a similar purpose and that appear to work well. They do not need to be doing exactly what the team does, as long as it can be compared. For example, if the team is dealing with problems in hospital laundry services, the team could learn from hotels and dormitories that provide similar services, although they are not in the same field and/or do not provide exactly the same service. Visit these sites and talk to managers and workers, asking them what they are doing, if they have similar problems, what they have done about it, and what levels of performance they have achieved. Ask as well what obstacles they have run into and how they have dealt with them. Identify other groups, organizations, or health facilities that serve a similar purpose and that appear to work well. They do not need to be doing exactly what the team does, as long as it can be compared. For example, if the team is		

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		comparable process. The evaluation helps the initiating organization identify shortcomings and establishes a baseline or standard against which to measure its progress in the development and maintenance of a quality assurance program. Used: • To develop options for potential solutions • To identify areas for improvement by seeing what level of quality is possible • When you want breakthrough improvements • When you need fresh ideas from outside your organization • After your own processes are well understood and under control Most useful when trying to develop options for potential solutions. When trying to develop solutions, teams often have difficulty generating new ideas. People frequently do not know what others nearby are doing. Benchmarking helps stimulate creativity by gaining knowledge of what has been tried. It can also be used to identify areas for improvement by seeing what level of quality is possible.	dealing with problems in hospital laundry services, the team could learn from hotels and dormitories that provide similar services, although they are not in the same field and/or do not provide exactly the same service. Visit these sites and talk to managers and workers, asking them what they are doing, if they have similar problems, what they have done about it, and what levels of performance they have achieved. Ask as well what obstacles they have run into and how they have dealt with them. Review how the situation and constraints for the process in question are similar to or different from theirs and determine if changes are needed in carrying out their plan. 1. Define a tightly focused subject of the benchmarking study. Choose an issue critical to the organization's success. 2. Form a cross-functional team. During the first step and this one, management's goals and support for the study must be firmly		

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			established. 3. Study your own process. Know how the work is done and measurements of the output. 4. Identify partner organizations that may have best practices. 5. Collect information directly from partner organizations. Collect both process descriptions and numeric data, using questionnaires, telephone interviews, and/or site visits. 6. Compare the collected data, both numeric and descriptive. 7. Determine gaps between your performance measurements and those of your partners. 8. Determine the differences in practices that cause the gaps. 9. Develop goals for your organization's process. 10. Develop action plans to achieve those goals. 11. Implement and monitor plans. 1. Identify what is to be benchmarked. Be specific in deciding what the team wants to benchmark.		

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			2. Decide which organizations/functions to benchmark. The comparison should be conducted not only against peers but also against recognized leading organizations with similar functions. 3. Determine the data collection method and collect data. Keep the data collection process simple. There is no one right way to benchmark. It is important to look outward, be innovative, and search for new and different ways to improve the process under study. 4. Contact a peer in the benchmark organization. Explain the purpose of the benchmarking study and what information is desired. Give assurance that confidential information will not be asked for. Proceed to inquire about the peer's organization: what they do, why they do it, how they measure and/or evaluate it and what their performance measures are, what has worked well, and what has not been successful. 5. Determine whether what the team has		

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			learned from benchmarking can be applied to improve the organization's process. Are there new and different ways to solve the problem or improve the process? Are there other solutions to the problem that the team has overlooked? It's important to keep an open mind about new and perhaps radically different ways of doing things. 1. Select the process to be benchmarked. 2. Establish a benchmarking team. 3. Understand and document the process to be benchmarked. 4. Establish performance measures for the process. 5. Compile a list of criteria that an ideal benchmarking partner should satisfy. 6. Search for potential benchmarking partners. 7. Compare the candidates and select one or more partners. 8. Establish contact with the selected partners and gain acceptance for their participation in the study. 9. Assess the information needs and		

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			information sources. 10. Select a method and tool for collecting data and information. 11. Perform data collection and debriefing. 12. Sort the collected information and data. 13. Quality control the collected information and data. 14. Normalize the data. 15. Identify gaps in performance levels. 16. Identify causes of the gaps. 17. Describe the ideal process and summarize improvement actions based on it. 18. Set targets for the improvements. 19. Develop an implementation plan, carry out the plan, and monitor the progress. 20. Write a final report form the benchmarking study. Resources: Benchmarking organization information Expertise: 1		

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Benefits and Barriers Exercise	Tague N. The tools. In: O'Mara P, editor. The quality toolbox. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2005. p. 93-521.	The benefits and barriers exercise helps individuals see both personal and organizational benefits of a proposed change. It also identifies perceived obstacles to accomplishing the change so they can be addressed in design. Most importantly, it generates individual and group buy-in to change. Used: • When trying to generate buy-in and support for a change • After a concept has been developed, but before detailed design of a plan, to identify obstacles that need to be considered in the design • When trying to decide whether to proceed with a change • Especially for major changes, such as launching a quality effort or implementing a recognition program	1. **Explain the purpose** of the exercise and how it will be done. Emphasize that everyone's active involvement is important. Divide the participants into groups of five to seven each and assign breakout rooms and leaders, who have been coached in advance on their role. 2. **Do benefits first**. Show the group this statement, written on flipchart paper and posted where all can see: "Assume that it is now two years in the future and we have been successful in implementing [name of concept or change]. What benefits do you see for yourself as an individual, for your group, and for the company as a whole?" 3. Within each small group, **brainstorm benefits** using the nominal group technique method. 4. Within each small group, **use multivoting to choose the top three benefits** in each of the three categories. Let each participant vote for his or her top five in each category. Each group selects a spokesperson. Allow 1 to 1 ½ hours for steps 3 and 4. 5. **Reassemble the**		

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Box and Whisker Plot (Also called: box plot)	Tague N. The tools. In: O'Mara P, editor. The quality toolbox. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2005. p. 93-521. American Society for Quality. Data collection and analysis tools: Box and whisker plot. 2009. Available at: http://www.asq.org/learn-about-quality/data-collection-analysis-tools/overview/box-whisker-plot.html. Accessed June 23, 2009.	A box and whisker plot is a graphical method of displaying variation in a set of data. In most cases a histogram provides a sufficient display; however, a box and whisker plot can provide additional detail while allowing multiple sets of data to be displayed in the same graph. Some types are called box and whisker plots with outliers. Used: • When analyzing or communicating the most important characteristics of a batch of data, rather than the detail • When comparing two or more sets of data • When there is not enough data for a histogram • When summarizing the data shown on another graph, such as a control chart or run chart	1. **List all the data values in order** from smallest to largest. We will refer to the total number of values, the count, as n. We will refer to the numbers in order like this, X1 is the smallest number; X2 is the next smallest number; up to Xn, which is the largest number. 2. **Medians**. Cut the data in half. Find the median—the point where half the values are larger and half are smaller. If the total number of values is even, the median is the average of the two middle ones. 3. **Hinges**. Cut the data in quarters. Find the hinges—the medians of each half. 4. **H-spread**. Calculate the distance between the hinges, or H-spread: H-spread = upper hinge—lower hinge. 5. **Inner fences**. These are values of separating data that are probably a predictable part of the distribution from data that are outside the distribution. Inner fences are located beyond each hinge at 1½ times the H-spread, a distance called a *step*. Upper inner fence =	Pros: Very effective and easy to read	

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			upper hinge + 1.5 x H-spread Lower inner fence = lower hinge—1.5 x H-spread 6. **Outer fences**. Data beyond these values are far outside the distribution and deserving of special attention. Outer fences are located one step beyond the inner fences. Upper outer fence = upper inner fence + 1.5 x H-spread Lower outer fence = lower inner fence—1.5 x H-spread 7. To **draw the box plot**, first draw one horizontal axis. Scale it appropriately for the range of data. Draw a box with ends at the hinge values. Draw a line across the middle of the box at the median value. Draw a line at each inner fence value. Draw a dashed crossbar at the adjacent value, the first value inside the inner fences. Draw whiskers, dashed lines from the ends of the box to the adjacent values. Draw small circles representing any outside data points: beyond the inner fences but inside the outer		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
			fences. Draw double circles to represent far out data points: beyond the outer fences. Note: If you are comparing several data sets, repeat the procedure for each set of data. 8. Analyze the plot. Look for: Location of the median Spread of the data: how far the hinges and fences are from the median Symmetry of the distribution Existence of outside points Expertise: 1 Resources: Data * Box and Whisker Plot template in ASQ		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
Brainwriting	Lighter D. Process orientation in health care quality. In: Moore C, editor. Quality management in health care: principles and methods. 2 ed. Sudbury, MA: Jones and Bartlett Publishers; 2004. p. 43-101. Tague N. The tools. In: O'Mara P, editor. The quality toolbox. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2005. p. 93-521. Andersen B. Tools for generating ideas and choosing among them. In: O'Mara P, editor. Business process improvement toolbox. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2007. p. 157-66. Mycoted. Creativity and innovation techniques. 2009. Available at: http://www.mycoted.com/Category:Creativity_Techniques. Accessed August 24, 2009.	A nonverbal form of brainstorming in which all ideas are written on sheets of paper by the individual team members, rather than verbalized. Brainwriting is a method of brainstorming in writing. The advantage of generating ideas through writing is that it is easier to describe more detailed and coherent ideas, which often leads to the development of equally coherent solutions. Brainwriting is a technique similar to brainstorming. There are many varieties, but the general process is that all ideas are recorded by the individual who thought of them. They are then passed on to the next person who uses them as a trigger for their own ideas. Used: • To generate ideas • When a broad range of options is desired • When creative, original ideas are desired • When participation of the entire group is desired • When participants might feel safer contributing ideas anonymously • To encourage equal participation, when verbal brainstorming sessions are typically dominated by a	1. Team members sit around a table. The facilitator **reviews the topic** or problem to be discussed. Often it is best phrased as a why, how, or what question. Make sure everyone understands the topic. 2. **Each team member writes up to four ideas** on a sheet of paper. He or she places the paper in the center of the table and selects another sheet that has a fellow team member's ideas on it. 3. **Up to four new ideas are added** to the list already on the sheet. These new ideas should build off the ideas already on the sheet. That sheet goes back in the center and another sheet is chosen. 4. **Continue this** way for a predetermined time (usually 15 to 30 min) or until no one is generating more ideas. 5. The sheets are collected for consolidation and discussion. 1. Team members are each given several sheets of paper. 2. As in brainstorming, the problem is presented as a "what,	Pros: Simple Relatively quick Makes it easy to follow up with an organizing tool like the affinity diagram Easier to describe more detailed and coherent ideas	

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
		few members • When some group members think better in silence • When ideas are likely to be complex and require detailed explanation	where, how" question. 3. Each team member then puts up to five ideas on each sheet and places the completed sheets in the center of the table. 4. The cycle continues until no new ideas are generated or 10 minutes have passed. 5. The sheets are consolidated, and a final list is created. 1. Team members sit around a table. The facilitator reviews the topic or problem to be discussed. Often it is best phrased as a why, how, or what question. Make sure everyone understands the topic. 2. Each team member writes up to four ideas on a sheet of paper. He or she places the paper in the center of the table and selects another sheet. 3. Up to four new ideas are added to the list already on the sheet. That sheet goes back in the center and another sheet is chosen. 4. Continue this way for a predetermined time (usually 15 to 30 min) or until no one is generating more ideas. The sheets are collected		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
			for consolidation and discussion. 1. As with brainstorming, start by clearly defining the target topic for the idea generation. The topic can be written on either a white board or the participants' individual cards if the card method is used. 2. The participants then write down their ideas, either on the cards or on the white board. Precise formulations are encouraged so as to enable understanding without explanation from the owner. 3. The participants are allowed to add to each others' ideas to reap the effects from combining ideas or further developing them. 4. At the end, the ideas are verbally discussed by the group and preferably also sorted into classes of ideas. 1. Present starter ideas: The leader initiates the process by placing several prepared sheets of paper in the pool in the centre of the table (see note below). 2. Private brainwriting: Each group member		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
			takes a sheet, reads it, and silently adds his or her ideas. 3. Change sheet: When a member runs out of ideas or wants to have the stimulation of another's ideas, s/he puts one list back in the centre of the table and takes one returned by another member. After reviewing this new list s/he has just selected, s/he adds more ideas. 4. Repeat until ideas are exhausted. No discussion at any stage. Expertise: 1 Resources: none		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
Cause-and-Effect Diagram (Also called: cause-and-effect analysis, Ishikawa or fishbone chart)	American Society for Quality. Cause analysis tools: Fishbone diagram. 2009. Available at: http://www.asq.org/learn-about-quality/cause-analysis-tools/overview/fishbone.html. Accessed June 26, 2009. University Research Co. LLC. Quality Assurance Project: Cause-and-effect analysis. 2008. Available at: http://www.qaproject.org/methods/resc&e.html. Accessed July 28, 2009. Besterfield D. Total quality management—tools and techniques. In: Krassow E, editor. Quality control. 8th ed. Upper Saddle River, NJ: Pearson Prentice Hall; 2009. p. 77-115. George M, Rowlands D, Price M, et al. Identifying and verifying causes. The lean six sigma pocket toolbook. New York: McGraw–Hill; 2005. p. 141-96. Tague N. The tools. In: O'Mara P, editor. The quality toolbox. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2005. p. 93-521.	The cause-and-effect diagram identifies many possible causes for an effect or problem. It can be used to structure a brainstorming session. It immediately sorts ideas into useful categories. A *cause-and-effect analysis* generates and sorts hypotheses about possible causes of problems within a process by asking participants to list all of the possible causes and effects for the identified problem. This analysis tool organizes a large amount of information by showing links between events and their potential or actual causes and provides a means of generating ideas about why the problem is occurring and possible effects of that cause. Cause-and-effect analyses allow problem solvers to broaden their thinking and look at the overall picture of a problem. Cause-and-effect diagrams can reflect either causes that block the way to the desired state or helpful factors needed to reach the desired state. The main stem of the fish bone leads to the defined problem, and the branches leading to the main stem represent major areas of concern and often fall into	1. Agree on problem statement. 2. Brainstorm major categories of causes of problem (methods, equipment, people, environment, etc.) 3. Write categories of causes as branches from main arrow 4. Brainstorm all possible causes of problem. Why does this happen? 5. Ask this again writing sub-causes branching off from causes. 6. When out of ideas, focus on places in diagram where there are few ideas. *Cause-and-effect diagram template in ASQ 1. Agree on the problem or the desired state and write it in the *effect* box. Try to be specific. Problems that are too large or too vague can bog the team down. 2. If using a tree or fishbone diagram, define six to eight major categories of causes. Or the team can brainstorm first about likely causes and then sort them into major branches. The team should add or drop categories as needed	Pros: • Able to continually ask “why,” to ensure each issue is broken down as far as possible • Broadens thinking about potential or real causes and facilitates further examination of individual causes • Helps identify the various causes affecting a process problem • Exposes gaps in existing knowledge of a problem • Can visually present a large number of root causes and issues in a relatively compact format • Helps identify lower level key characteristics and key process parameters affecting key characteristics • Helps a group reach a common understanding of a problem • Helps reduce the incidence of uniformed decisionmaking Cons: • Does not tell which is the root cause, only possible causes	Nagaraju D. Improvement of hospital discharge process by value stream mapping. 17th Annual Society for Health Systems Management Engineering Forum; 2005; Dallas, TX; 2005. McCray M. How to get paid for the services you provide. 2007 Society for Health Systems Conference; 2007; New Orleans, LA; 2007.

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
	Bauer J, Duffy G, Westcott R, editors. The quality improvement handbook, Improvement Tools. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2006. p. 109-48. Andersen B. Tools for analyzing the performance shortcoming. In: O'Mara P, editor. Business process improvement toolkit. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2007. p. 123-55. The Boeing Company. Advanced quality system tools. 1998. Available at: http://www.boeing.com/companyoffices/doingbiz/supplier/d1-9000-1.pdf. Accessed August 24, 2009. Mind Tools Ltd. Cause and effect diagrams. 2009. Available at: http://www.mindtools.com/pages/article/newTMC_03.htm. Accessed August 24, 2009. Mycoted. Creativity and innovation techniques. 2009. Available at: http://www.mycoted.com/Category:Creativity_Tech	categories such as people, materials, equipment, measurement, or environment. A cause-and-effect diagram is a picture composed of lines and symbols designed to represent a meaningful relationship between an effect and its causes. The cause-and-effect diagram graphically illustrates the relationship between a given outcome and all the factors that influence the outcome. It displays the factors that are thought to affect a particular output or outcome in a system. The factors are often shown as grouping of related subfactors that act in concert to form the overall effect of the group. The cause-and-effect chart is one of the classical and most widely used tools in quality management. The main purpose is, as the name implies, to identify possible causes of an effect. The effect being analyzed can be an experienced problem or a future hoped-for state where the causes no longer occur. A tool used to graphically display the relationship between an effect (e.g., a	when generating causes. Each category should be written into the box. 3. Identify specific causes and fill them in on the correct branches or sub-branches. Use simple brainstorming to generate a list of ideas before classifying them on the diagram, or use the development of the branches of the diagram first to help stimulate ideas. If an idea fits on more than one branch, place it on both. Be sure that the causes as phrased have a direct, logical relationship to the problem or effect stated at the head of the fishbone. Each major branch (category or step) should include three or four possible causes. If a branch has fewer, lead the group in finding some way to explain this lack, or ask others who have some knowledge in that area to help. 4. Keep asking "Why?" and "Why else?" for each cause until a potential root cause has been identified. A root cause is one that: (a) can explain the "effect," either directly or through a series of events, and		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
	niques. Accessed August 24, 2009. Tidd J, Bessant J, Pavitt K. Innovation management toolbox. 2001. Available at: http://www.wiley.co.uk/wileychi/innovate/website/pages/atoz/atoz.htm. Accessed August 24, 2009.	problem or key characteristic) and the causes that influence it. Used: • When identifying possible causes for a problem. • To focus attention on the process where a problem is occurring and to allow for constructive use of facts revealed by reported events • To investigate a "bad" effect and to take action to correct the causes • To investigate a "good" effect and to learn those causes responsible • To analyze actual conditions for the purpose of product or service quality improvement, use resources more efficiently, and reduce costs • To eliminate conditions causing nonconforming product or service and customer complaints • To standardize existing and proposed operations • To educate and train personnel in decisionmaking and corrective-action activities • To help teams push beyond symptoms to uncover potential root causes • To provide structure to cause identification effort • To ensure that a balanced list of ideas have been	(b) if removed, would eliminate or reduce the problem. Try to ensure that the answers to the "Why" questions are plausible explanations and that, if possible, they are amenable to action. Check the logic of the chain of causes: read the diagram from the root cause to the effect to see if the flow is logical. Make needed changes. 5. Have the team choose several areas they feel are most likely causes. These choices can be made by voting to capture the team's best collective judgment. Use the reduced list of likely causes to develop simple data collection tools to prove the group's theory. If the data confirm none of the likely causes, go back to the cause-and-effect diagram and choose other causes for testing. 1. Determine the major problem for analysis. 2. Assemble a team of improvement professionals as well as operations staff concerned with the problem. 3. Construct the main		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
		generated during brainstorming or that major possible causes are not overlooked • For cause identification once you have a focused definition of the problem • As a cause-prevention tool by brainstorming ways to maintain or prevent future problems • To focus on a specific issue without resorting to complaints and irrelevant discussion • To identify areas where there is a lack of data • Performing key characteristic flowdown • Looking for all potential causes of a problem • Organizing brainstorming lists into causes and effects • Identify sources of process variation • Linking process output to process parameters It can help to focus attention on the process where a problem is occurring and to allow for constructive use of facts revealed by reported events.	stem of the diagram with the problem described at the end. 4. Brainstorm the major concerns as branches off the main stem. 5. Once the major concern branches are complete, combine any that are redundant or that should be subbranches. 6. After the group has agreed on the major branches, brainstorm each branch for root causes. 7. After the root causes are identified, combine any that are redundant. 8. Brainstorm root causes for any other factors that should be included as causes on the chart under the root cause branches. 1. Name the problem or effect of interest. Be as specific as possible. 2. Decide the major categories for causes and create the basic diagram on a flip chart or whiteboard. 3. Brainstorm for more detailed causes and create the diagram. 4. Review the diagram for completeness. 5. Discuss the final diagram. Identify causes you think are most		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
			critical for follow-up investigation. 6. Develop plans for confirming that the potential causes are actual causes. DO NOT GENERATE ACTION PLANS until you've verified the cause. 1. Draw a long horizontal line with a box at the far right end of the line. 2. Indicate in the box at the far right of the diagram what effect, output, or improvement goal is being portrayed. The effect can be positive (an objective) or negative (a problem). When possible use a positive effect instead of a negative one as the effect to be discussed. Focusing on problems can produce "finger-pointing," whereas focusing on desired outcomes fosters pride and ownership over productive areas. The resulting positive atmosphere will enhance the group's creativity. 3. Draw four diagonal lines emanating from the horizontal line. Terminate each diagonal line with a box. 4. Label the boxes on		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
			the diagonal lines to show the four categories potential major causes (Men/Women, Machines, Methods, and Materials or, alternatively, Policies, Procedures, People, and Plant). The team can substitute other category names if desired. 5. On each of the four diagonal lines, draw smaller horizontal lines (smaller "bones") to represent subcategories and indicate on these lines information that is thought to be related to the cause. Draw as many lines as are needed, making sure that the information is legible. Use an idea-generating technique to identify the factors and subfactors within each major category. 6. Use the diagram as a discussion tool to better understand how to proceed with process improvement efforts. The diagram can also be used to communicate the many potential causes of quality that impact the effect/output/improvement goal. Look for factors that appear repeatedly and list them. Also, list		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
			those factors that have a significant effect, based on the data available. Keep in mind that the location of a cause in your diagram is not an indicator of its importance. A subfactor may be the root cause of all of the problems. You may also decide to collect more data on a factor that has not been previously identified. 1. **Assemble a suitable group** of individuals who possess the necessary knowledge about the area to be analyzed. 2. **Clearly describe the effect** for which causes are sought. This effect is often a low performance level for one of the business processes of the organization. 3. Using a white board or some other large medium, **draw the effect** at the end of a large arrow. The point is to set aside enough space for the generated causes, not symmetry or nice drawing effects. 4. **Identify the main categories** of possible causes of the effect and place these at branches emanating from the large arrow. For service		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
			processes, the traditional categories are people, processes, framework conditions, and work environment. 5. **Brainstorm all possible causes** and place these in the suitable area of the chart. Emphasize brief and succinct descriptions. Proceed through the chart one main category at a time, but also include suggestions that belong to categories other than the one currently being treated. Causes that belong to more than one category are placed in all relevant positions. It is often required to redraw the chart after the first version has been completed. 6. **Analyze the identified causes** to determine those that should be addressed further. Remember that the purpose is to cure the problem, not the symptoms. 1. Generate potential causes of a problem (or effect) through structured brainstorming. 2. Place the problem statement, event, or key characteristic in a box		

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			on right-hand side of paper. 3. Draw a horizontal line to the left. 4. Decide upon the major cause categories of the event, problem, or key characteristics. 5. Write the major cause categories on the left-hand side of paper and draw lines to them off the main horizontal line. 6. When evaluating for causes, all the major potential sources should be reviewed: machines, methods, materials, people, measurements, and environment. 7. Place the brainstormed ideas under the appropriate major cause category. Add any newly identified causes. 8. For each cause, ask, “Why does it happen?” And list responses as branches off the major cause branches. 9. Continue this process to the root-cause level. 10. Identify the most influential causes and focus activities on them. Expertise: 1 Resources: flip chart		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
Checklist (Also called: Check Sheet)	Woodward H, Suskovich D, Workman-Germann J, et al. Adaptation of lean methodologies for healthcare applications. 2007 Society for Health Systems Conference; 2007; New Orleans, LA; 2007. American Society for Quality. Data collection and analysis tools: Check sheet. 2009. Available at: [http://www.asq.org/learn-about-quality/data-collection-analysis-tools/overview/check-sheet.html. Accessed July 23](http://www.asq.org/learn-about-quality/data-collection-analysis-tools/overview/check-sheet.html), 2009. Besterfield D. Total quality management—Tools and techniques. In: Krassow E, editor. Quality Control. 8th ed. Upper Saddle River, NJ: Pearson Prentice Hall; 2009. p. 77-115. Tague N. The tools. In: O'Mara P, editor. The quality toolbox. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2005. p. 93-521. Bauer J, Duffy G, Westcott R, editors. The quality improvement handbook, Improvement Tools. 2nd ed. Milwaukee, WI: ASQ	A check sheet is a table or form used for registering data as they are collected. It is a simple, generic tool that can easily convert collected data into readily useful information. One of the main applications is registering how often different problems or incidents occur. This provides important information about problem areas or probable causes of errors, and thus provides a good foundation for deciding where to concentrate during improvement. A worksheet used to collect qualitative process output data, such as adherence data to protocols or clinical standards. A check sheet is a structured, prepared form for collecting and analyzing data. This is a generic tool that can be adapted for a wide variety of purposes. The main purpose of check sheets is to ensure that data are collected carefully and accurately by operating personnel for process control and problem solving. A check sheet is a form used to record the frequency of specific events during a data collection period. It is a simple form that you can use	1. **Agree on what events** are to be recorded. These must be clearly defined to avoid doubt whether an event truly occurred. It is usually also smart to include a category of "other" to capture incidents that are not easy to otherwise categorize. 2. **Determine the time period** during which the data will be collected. Note: If data is being collected over specified time intervals (e.g. every 15 minutes), determine which intervals will be used. 3. **Design a form** that is clear and easy to use, making sure that all categories are clearly labeled and that there is enough space to enter the data. 4. **Perform data collection** during the agreed period. In advance, it is necessary to make sure that everyone taking part in the data collection has a common understanding of the task, so as to achieve consistency in the data material. 5. When data collection is completed, **analyze the material** to identify events displaying a high	Pros: • Builds confidence in the reliability and repeatability of collected data • Easy to make and use • Data collected can be used in histogram, bar chart, Pareto chart, etc. • Collects and displays data easily • Collects factual information about the process being studied • Answers the question, "How often are certain events happening?" • Prioritizes efforts where most problems occur Cons: • Check sheet form needs to be individualized for each situation	Appendix A: Primary care workbook. In: Nelson E, Batalden P, Godfrey M, editors. Quality By Design: A Clinical Microsystems Approach. San Francisco: Jossey-Bass; 2007. p. 385-431. Medical Group Management Association. Billing process checklist. Englewood, CO 2005. Medical Group Management Association. Electronic medical record (EMR) checklist. Englewood, CO 2003. Medical Group Management Association. Compliance audit/risk assessment Englewood, CO; 2005.

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
	Quality Press; 2006. p. 109-48. Andersen B. Tools for collecting data about the performance shortcoming. In: O'Mara P, editor. Business process improvement toolkit. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2007. p. 107-22. The Boeing Company. Advanced quality system tools. 1998. Available at: http://www.boeing.com/companyoffices/doingbiz/supplier/d1-9000-1.pdf. Accessed August 24, 2009.	to collect data in an organized manner and easily convert it into readily useful information. A check sheet is a table or form used for registering data as they are collected. One of the main applications is registering how often different problems or incidents occur. This provides important information about problem areas or probable causes of errors, and thus provides a good foundation for deciding where to concentrate during improvement. A data-collection form used to manually tally and record the number of observations or occurrences of certain events during a specified time period. The data collected can be either attribute (e.g., defects) or variable (e.g., measurements). Used: • When data can be observed and collected repeatedly by the same person or location • When collecting data on the frequency or patterns of events, problems, defects, defect location, defect causes, etc. • When collecting data from a production process	number of occurrences. These will contribute to the prioritization of what specific areas within the chosen business process should be emphasized in the ensuing improvement work. Note: A suitable visual aid for presenting results is a Pareto chart, histogram, or bar chart. 1. Decide what event or problem will be observed. Develop operational definitions. 2. Decide when data will be collected and for how long. 3. Design the form. Set it up so data can be recorded by making check marks or X's or something similar. 4. Label all spaces on the form. 5. Pilot test check sheet to ensure it collects appropriate data and its ease of use. 6. Each time targeted event or problem occurs, record data on check sheet. *Check sheet template in ASQ 1. Clarify the measurement objectives. Ask questions such as		

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		• To collect data with minimal effort • To convert raw data into useful information • To translate perceptions of what is happening into what is actually happening • Conducting a problem-solving exercise • Troubleshooting a process • Observing the behavior of a process • Building a histogram • Gathering data in order to detect patterns	"What is the problem?" "Why should data be collected?" "Who will use the information being collected?" and "Who will collect the data?" 2. Create a form for collecting data. Determine the specific things that will be measured and write them down the left side of the check sheet. Determine the time or place being measured and write this across the top of the columns. 3. Label the measure for which data will be collected. 4. Collect the data by recording each occurrence directly on the check sheet as it happens. 5. Tally the data by totaling the number of occurrences for each category being measured. 6. The data from the check sheet can be summarized in a number of ways, such as with a Pareto chart or a histogram. 1. Agree on what events are to be recorded. These must be clearly defined to avoid doubt whether an event truly occurred. It is usually		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
			also smart to include a category of “other” to capture incidents that are not easy to otherwise categorize. 2. Define the period for data recording and a suitable division into intervals. 3. Design the check sheet to be used during recording. Make sure that space is allocated for recording each event and summarizing both within the intervals and for the entire recording period. 4. Perform data collection during the agreed period. In advance, it is necessary to make sure that everyone taking part in the data collection has a common understanding of the task, so as to achieve consistency in the data material. 5. When data collection is completed, analyze the material to identify events displaying a high number of occurrences. These will contribute to the prioritization of what specific areas within the chosen business process should be emphasized in the ensuing improvement work. A suitable visual aid for this analysis is a		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
			Pareto chart. 1. The process to be observed is agreed upon by the team. 2. Decide on the time period during which data will be collected. 3. Decide whether data will be variable or attribute; define data categories. 4. Design a form that is clear and easy to use, making sure that all categories are clearly labeled and that there is enough space to enter the data. 5. Train the people who work in the process how to collect the data. 6. Collect the data by making a mark in the correct category for each observation, making sure that samples are as representative as possible. 7. Analyze the data for opportunities for process improvement. Expertise: 1 Resources: none		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
Cognitive Task Analysis	Crandall B, Klein G, Hoffman RR. Working minds: a practitioner's guide to cognitive task analysis. London: The MIT Press; 2006.	The purpose of cognitive task analysis is to capture the way the mind works, to capture cognition. The researcher or practitioner carrying out a CTA study is usually trying to understand and describe how the participants view the work they are doing and how they make sense of the events. If they are taking effective action and managing complex circumstances well, the CTA should describe the basis for their skilled performance. If they are making mistakes, the CTA study should explain what accounts for the mistakes. CTA studies try to capture what people are thinking about, what they are paying attention to, the strategies they are using to make decisions or detect problems, what they are trying to accomplish, and what they know about the way a process works. Used: • To capture the way the mind works • To understand and describe how the participants view the work they are doing and how they make sense of the events			Baxter GD, Monk AF, Tan K, et al. Using cognitive task analysis to facilitate the integration of decision support systems into the neonatal intensive care unit. Artif Intell Med 2005;35(3):243-57. Rinkus SM, Chitwood A. Cognitive analyses of a paper medical record and electronic medical record on the documentation of two nursing tasks: Patient education and adherence assessment of insulin administration. Proceedings of the AMIA Symposium 2002:657-61.

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
Cognitive Walkthrough	Stanton N, Salmon P, Walker G, et al. Task analysis methods. Human factors methods: a practical guide for engineering and design. Great Britain: Ashgate; 2005. p. 45-76.	The cognitive walkthrough method is used to evaluate user interface usability. The main driver behind the development of the method was the goal to provide a theoretically based design methodology that could be used in actual design and development situations. Used: • To evaluate user interface usability	1. **Select tasks to be analyzed**. Firstly, the analyst should select the set of tasks that are to be the focus of the analysis. In order to ensure that the user interface in question is subjected to a thorough examination, an exhaustive set of tasks should be used. However, if time is limited, then the analyst should try to select a set of tasks that are as representative of the tasks that can be performed with the interface under analysis as possible. 2. **Create task descriptions**. Each task selected by the analyst must be described fully from the point of the user. Although there are a number of ways of doing this, it is recommended that a hierarchal task analysis (HTA) describing the general operation of the user interface under analysis is used. An exhaustive HTA should provide a description of each task identified during step 1. 3. **Determine the correct sequence of actions**. For each of the selected tasks, the	Pros: • Presents a structured approach to user interface analysis • Used early in the design lifecycle of an interface. This allows any design flaws highlighted in the analysis to be eradicated. • Designed to be used by non-cognitive psychology professionals • Cognitive walkthrough method is based upon sound underpinning theory, including Norman's model of action execution • Easy to learn and apply • Output from a cognitive walkthrough analysis appears to be very useful Cons: • Limited to cater only for ease of learning of an interface • Requires validation • May be time consuming for complex tasks • Large part of the analysis is based upon analyst subjective judgment • Requires access to the personnel involved in the task(s) under analysis	

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			appropriate sequence of actions required to complete the task must be specified. Again, it is recommended that the analyst uses the HTA for this purpose. 4. **Identify user population**. Next, the analyst should determine the potential users of the interface under analysis. A list of user groups should be created. 5. **Describe the user's initial goals**. The final part of the cognitive walkthrough analysis preparation phase involves identifying and recording the user's initial goals. The analyst should record what goals the user has at the start of the task. This is based upon the analyst's subjective judgment. Again, it is recommended that the HTA output is used to generate the goals required for this step of the analysis. 6. **Analyze the interaction between user and interface**. The second and final phase of the cognitive walkthrough procedure, the evaluation phase, involves analyzing the interaction between the		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
			user and the interface under analysis. To do this, the analyst should 'walk' through each task, applying the criteria outlined above as they go along. The cognitive walkthrough evaluation concentrates on three key aspects of the user interface: The relationship between the required goals and the goals that the user actually has The problems in selecting and executing an action Changing goals due to action execution and system response The analyst should record the results for each task step. This can be done via video, audio or pen and paper techniques. Expertise required: 2 Resources: none		

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Comms Usage Diagram (CUD)	Stanton N, Salmon P, Walker G, et al. Team assessment methods. Human factors methods: a practical guide for engineering and design. Great Britain: Ashgate; 2005. p. 365-429.	Comms Usage Diagram (CUD)is used to describe collaborative activity between teams of actors dispersed across different geographical locations. A CUD output describes how and why communications between actors occur, which technology is involved in the communication, and the advantages and disadvantages associated with the technology used. The CUD method was originally developed and applied in the area of medical telecommunications and was used to analyze telemedical consultation scenarios. Used: • To analyze communications between actors when technology is used • To analyze teamwork and distributed collaboration	1. **Define the task or scenario under analysis**. The first step in a CUD analysis is to clearly define the task or scenario under analysis. It may be useful to conduct a HTA of the task under analysis for this purpose. A clear definition of the task under analysis allows the analyst(s) to prepare for the data collection phase. 2. **Data collection**. Next, the analyst(s) should collect specific data regarding the task or scenario under analysis. A number of data collection procedures may be used for this purpose, including observational study, interviews and questionnaires. It is recommended that specific data regarding the activity conducted, the actors and individual task steps involved, the communication between actors, the technology used and the different geographical locations should be collected. 3. **Create task or scenario transcript**. Once sufficient data regarding the task under analysis has been collected, a transcript of	Pros: • The CUD method is simple to use and requires only minimal training • The CUD output is particularly useful, offering a description of the task under analysis, and also a description of the communications between actors during the task, including the order of activity, the personnel involved, the technology used and the associated advantages and disadvantages. • The output of a CUD analysis is particularly useful for highlighting communication flaws in a particular network • The CUD method is particularly useful for the analysis of teamwork, distributed collaboration and C4i activity • The CUD method is also flexible, and could potentially be modified to make it comprehensive. Factors such as time, error, and workload could potentially be incorporated, ensuring that a much more exhaustive analysis is produced. • Although the CUD method was developed and originally used in the medical domain, it is a generic method and could potentially be applied in any domain involving distributed collaboration or activity	

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			the task or scenario should be created using the data collected as its input. The transcript should contain all of the data required for the construction of the CUD i.e. the communications between different actors and the technology used. 4. **Construct CUD**. The scenario transcript created during step 3 of the procedure is used as the input into the construction of the CUD. The CUD contains a description of the activity conducted at each geographical location, the communication between the actors involved, the technology used for the communications and the advantages and disadvantages associated with that technology medium and also a recommended technology if there is one. Arrows are used to represent the communication and direction of communication between personnel at each of the different locations. Column three of the CUD output table specifies the technology used in the	Cons: • For large, complex tasks involving multiple actors, conducting a CUD analysis may become time consuming and laborious • The initial data collection phase of the CUD method is also time consuming and labor intensive, potentially including interviews, observational analysis and talk-through analysis. As the activity is dispersed across different geographical locations, a team of analysts is also required for the data collection phase. • No validity or reliability data are available for the method • Application of the CUD method appears to be limited • Limited guidance is offered to analysts using the method since part of it is based upon the analyst's subjective judgment	

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			communication and column four lists any advantages and disadvantages associated with the particular technology used during the communication. In column five, recommended technology mediums for similar communications are provided. The advantages, disadvantages and technology recommendations are based upon analyst subjective judgment. Expertise: 2 Resources: none		

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Contingency Diagram	Tague N. The tools. In: O'Mara P, editor. The quality toolbox. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2005. p. 93-521.	The contingency diagram uses brainstorming and a negative thinking process to identify how process problems occur or what might go wrong in a plan. Then the negative thinking is reversed to generate solutions or preventive measures. Used: • When identifying problem causes • When developing solutions to problems • When planning implementation of a phase of a project, especially the solution • Before launching a change • Especially when negative thinking is preventing the group from generating ideas	1. **Identify your topic**—the problem or the proposed action plan—and write it prominently on a flipchart. 2. **Brainstorm** how to make thing go wrong. For a problem: • How can we make the problem happen? • How could we make it worse? • For a plan or action: • How can our plan be made to fail? • What assumptions are we making that could turn out to be wrong? Write each idea on the flipchart in words as close as possible to those used by the contributor. 3. When no more ideas are being generated, **reverse your thinking**. For each idea on the flipchart, describe actions that would prevent it. Write these beside or under the problem actions, in a different color. 4. When each negative idea has been reversed, **think more broadly**: modifying ideas, combining ideas, extending patterns, and other creative thinking techniques. Expertise: 1	Pros: • Creates production or progress out of negative thinking	

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
			Resources: Flipchart		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
Cost-of-Poor-Quality Analysis (Also called: cost-of-quality analysis, red and green circle exercise)	Tague N. The tools. In: O'Mara P, editor. The quality toolbox. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2005. p. 93-521.	A cost-of-poor-quality analysis is a way of studying a process's flowchart to identify potential problems. *Cost of poor quality* means costs incurred because things are not done right the first time and every time. The analysis helps a team look critically at individual steps of a process to find opportunities for improvement. Used: • When flowcharting a process, to be sure that cost-of-poor-quality activities are included • After flowcharting a process, to identify problems, potential causes, and areas in which to concentrate improvement efforts	1. Obtain or draw a detailed flowchart of the process. 2. **Identify all process steps** (including recycle loops) that incur costs of quality: inspection, fix, and damage control. Draw a red circle (red for *Stop*) around those steps or recycles. Note: If few or no steps have red circles, ask, "What can go wrong? How do we tell if things go wrong? How does the process handle things going wrong?" If necessary, add missing steps to the flowchart that show how problems are handled. 3. **For each red circle**, ask, "What process step, done perfectly, would allow us to eliminate this red-circled step?" Draw a green circle (green for *Go*) around each step identified here. 4. **The green circles show steps to examine** for ways to prevent problems and to seek improvement in general. Green circles will contain the root causes of problems identified by the red circles. Expertise: 1	Cons: • Need to have a flowchart of the process in order to use	

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
			Resources: sticky notes, flipchart		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
Critical Decision Method (CDM)	Stanton N, Salmon P, Walker G, et al. Cognitive task analysis methods. Human factors methods: a practical guide for engineering and design. Great Britain: Ashgate; 2005. p. 77-108.	The Critical Decision Method (CDM; Klein and Armstrong, 2004) is a semi-structured interview technique that uses cognitive probes in order to elicit information regarding expert decisionmaking. The method is an extension of the Critical Incident Technique and was developed in order to study the naturalistic decisionmaking strategies of experienced personnel. Used: • To provide knowledge engineering for expert system development, identify training requirements, generate training materials and evaluate the task performance impact of expert systems	1. **Define the task or scenario under analysis**. The first part of a CDM analysis is to define the incident that is to be analyzed. CDM normally focuses on non-routine incidents, such as emergency incidents, or highly challenging incidents. 2. **Select CDM probes**. The CDM method works by probing subject-matter experts (SMEs) using specific probes designed to elicit pertinent information regarding the decisionmaking process during key points in the incident under analysis. In order to ensure that the output is compliant with the original aims of the analysis, an appropriate set of CDM probes should be defined prior to the analysis. The probes used are dependent upon the aims of the analysis and the domain in which the incident is embedded. Alternatively, if there are no adequate probes available, the analyst(s) can develop novel probes based upon the analysis needs. 3. **Select appropriate participant**. Once the	Pros: • Can be used to elicit specific information regarding the decisionmaking strategies used by agents in complex, dynamic systems • Method is normally quick in application • Once familiar with method, CDM is relatively easy to apply • Popular procedure and has been applied in a number of domains • CDM output can be used to construct propositional networks which describe the knowledge or SA objects required during the scenario under analysis Cons: • Reliability of such a method is questionable • Data obtained is highly dependent upon the skill of the analyst conducting the CDM interview and also the quality of the participant used • A high level of expertise and training is required in order to use the CDM to its maximum effect • Relies upon interviewee verbal reports in order to reconstruct incidents. How far a verbal report accurately represents the cognitive processes of the decision maker is questionable. • Often difficult to gain sufficient access to appropriate SMEs in order to	

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
			scenario under analysis and the probes to be used are defined, an appropriate participant or set of participants should be identified. The SMEs used are typically the primary decision maker in the task or scenario under analysis. 4. **Gather and record account of the incident**. The CDM procedure can be applied to an incident observed by the analyst or to a retrospective incident described by the participant. If the CDM analysis is based upon an observed incident, then this step involves firstly observing the incident and then recording an account of the incident. Otherwise, the incident can be described retrospectively from memory by the participant. The analyst should ask the SME for a description of the incident in question, from its starting point to its end point. 5. **Construct incident timeline**. The next step in the CDM analysis is to construct a timeline of the incident described in step 4. The aim of this is to give the analyst(s) a	conduct a CDM analysis	

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
			clear picture of the incident and its associated events, including when each event occurred and what the duration of each event was. Theevents included in the timeline should encompass any physical events, such as alarms sounding, and also 'mental' events, such as the thoughts and perceptions of the interviewee during the incident. 6. Once the analyst has a clear understanding of the incident under analysis, **the incident should be divided into key phases or decision points**. It is recommended that this is done in conjunction with the SME. Normally, the incident is divided into four or five key phases. 7. **Use CDM probes to query participant decisionmaking**. For each incident phase, the analyst should probe the SME using the CDM probes selected during step 2 of the procedure. The probes are used in an unstructured interview format in order to gather pertinent information regarding		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
			the SME's decisionmaking during each incident phase. The interview should be recorded using an audio recording device. 8. **Transcribe interview data**. Once the interview is complete, the data should be transcribed accordingly. 9. **Construct CDM tables**. Finally, a CDM output table for each scenario phase should be constructed. This involves simply presenting the CDM probes and the associated SME answers in an output table. Expertise: 3 Resources: audio recorder		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
Critical Incident	Andersen B. Tools for analyzing the performance shortcoming. In: O'Mara P, editor. business process improvement toolkit. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2007. p. 123-55. Stanton N, Salmon P, Walker G, et al. Cognitive task analysis methods. Human factors methods: a practical guide for engineering and design. Great Britain: Ashgate; 2005. p. 77-108.	Critical incident is a technique that can be used for identifying a process, subprocess, or problem that should be improved. After you've completed this task and are in progress with an improvement project, it is also useful for figuring out what is causing the performance shortcoming. It is a quite open and frank way of seeking information about organizational problems. The technique relies on honest responses from those involved, and a prerequisite is that the participants are completely free to express their views. In this respect, it is important that management display the right attitude to avoid censorship or withholding of information in fear of consequences from being too honest. Used: • For identifying a process, subprocess, or problem that should be improved • For what is causing a performance shortcoming	1. First, the **participants in the analysis are selected**, and this should include people actively involved in the process being improved. 2. Next, the group of participants is asked to answer questions such as the following: • Which incident last week was the most difficult to handle? • Which episode created the biggest problems in terms of maintaining customer satisfaction? • Which incident cost the most in terms of additional resources or direct expenditures? • The purpose is to focus on the critical incidents that, in one way or another, created problems for the employees, the organization, or other stakeholders. The period covered by the questions can range from a few days to several months. It is, however, not favorable if the period is too long, as it might be difficult to determine the most critical incident simply because many incidents can qualify as candidates given a	Pros: • Simple and straightforward	

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
			sufficient length of time. 3. **The collected answers are sorted and analyzed** according to the number of times the different incidents have been mentioned. A graphical representation format might very well be used for this purpose. The incidents occurring most often, such as the critical ones, are obvious candidates for prevention of recurrence. Expertise: 1 Resources: none		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
Critical Incident Technique (CIT)	Stanton N, Salmon P, Walker G, et al. Cognitive task analysis methods. Human factors methods: a practical guide for engineering and design. Great Britain: Ashgate; 2005. p. 77-108.	Critical incident technique (CIT) is an interview method that is used to retrospectively analyze operator decisionmaking. The CIT involves the use of semi-structured interviews to facilitate operator recall of critical events or incidents, including the actions and decisions made by themselves and colleagues and the reasons why they made them. The analyst uses a set of probes designed to elicit pertinent information surrounding the participant's decisionmaking during the scenario under analysis. Used: • To analyze operator decisionmaking	1. **Select the incident to be analyzed**. The first part of CIT analysis is to select the incident or group of incidents that are to be analyzed. Depending upon the purpose of the analysis, the type of incident may already be selected. CIT normally focuses on the non-routine incidents, such as emergency scenarios, or highly challenging incidents. If the type of incident is not already known, CIT analysts may select the incident via interview with system personnel, probing the interviewee for recent high risk, highly challenging, emergency situations. The interviewee involved in the CIT analysis should be the primary decision maker in the chosen incident. CIT can also be conducted on groups of operators. 2. **Gather and record account of the incident**. Next the interviewee(s) should be asked to provide a description of the incident in question, from its starting point (i.e. alarm sounding) to its end point (i.e. when the incident was classed	Pros: • The CIT can be used to elicit specific information regarding decisionmaking in complex systems • Once learned, the method requires relatively little effort to apply • The incidents which the method concentrates on have already occurred, removing the need for time consuming incident observations • Has been used extensively in a number of domains and has the potential to be used anywhere • CIT is a very flexible method • High face validity Cons: • Reliability of such a method is questionable • A high level of expertise in interview methods is required • After the fact data collection has a number of concerns associated with it, such as degradation, correlation with performance etc. • Relies upon the accurate recall of events • Operators may not wish to recall events or incidents in which their performance is under scrutiny • The data obtained is dependent upon the skill of the analyst and also the quality of the subject-matter experts (SMEs) used • The original CIT probes are	

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
			as 'under control'). 3. The next step in the CIT analysis is to **construct an accurate timeline** of the incident under analysis. The aim of this is to give the analysts a clear picture of the incident and its associated events, including when each event occurred and what the duration of each event was. The events included in the timeline should encompass any physical events, such as alarms sounding, and also 'mental' events, such as the thoughts and perceptions of the interviewee during the incident. 4. **Select required incident aspects**. Once the analyst has an accurate description of the incident, the next step is to select specific incident points that are to be analyzed further. The points selected are dependent upon the nature and focus of the analysis. 5. **Each incident aspect selected in step 4 should be analyzed further** using a set of specific probes. The probes used are dependent upon the	dated and the method has effectively been replaced by the critical decision method (CDM)	

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
			aims of the analysis and the domain in which the incident is embedded. The analyst should develop specific probes before the analysis begins. In an analysis of team communication, the analyst would use probes such as ‘Why did you communicate with team member B at this point?’, ‘How did you communicate with team member B?’, ‘Was there any miscommunication at this point?’ etc. Expertise: 2 Resources: none		

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Critical Path Method (CPM) (Also called: Critical Path Analysis, arrow diagram, activity network diagram, network diagram, activity chart, node diagram)	Fox J, Black E, Chronokis I, et al. From guidelines to careflows: Modelling and supporting complex clinical processes. In: Teije A, Miksch S, Lucas P, editors. Computer-based medical guidelines and protocols: a primer and current trends. The Netherlands: IOS Press; 2008. p. 44-62. Internet Center for Management and Business Administration I. ICMBA: PERT. 2007. Available at: http://www.netmba.com/operations/project/pert/. Accessed July 22, 2009. American Society for Quality. Seven new management and planning tools: Arrow diagram. 2009. Available at: http://www.asq.org/learn-about-quality/new-management-planning-tools/overview/arrow-diagram.html. Accessed July 23, 2009. Tague N. The tools. In: O'Mara P, editor. The quality toolbox. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2005. p. 93-521.	The Critical Path Method (CPM) shows the required order of tasks in a project or process, the best schedule for the entire project, and potential scheduling and resource problems and their solutions. It lets you calculate the "critical path" of the project. This is the flow of critical steps where delays will affect the timing of the entire project and where addition of resources can speed up the project. Was developed for scheduling a set of activities in any project with interdependent activities. The essential technique is to develop a model of all the activities required to complete the project, the time that each activity will take to completion, and the dependencies between the activities. The Critical Path Method (CPM) is a deterministic method that uses a fixed time estimate for each activity. The critical path is determined by adding the times for the activities in each sequence and determining the longest path in the project. The critical path determines the total calendar time required for the project.	1. For each activity determine the earliest start time, earliest finish time, latest start time, and latest finish time 2. Find the longest path in terms of time (path has no slack) 3. Calculate the variance in project completion time by summing the variances in completion times of each activity. 4. Can calculate the probability the project will be completed by a certain date assuming normal probability distribution for the critical path. 1. **List all necessary tasks** in project or process. 2. Determine correct sequence of tasks. a. Which tasks must happen before another begins? b. Which tasks can be done at the same time as others? c. Which tasks should happen immediately after another? 3. **Diagram the network of tasks** with time flowing from left to right. 4. Between each two tasks, **draw circles for**	Pros: • Generally easy to understand and use • Analyzes a project's schedule more thoroughly than a Gantt chart Cons: • Need detailed knowledge of all the stages of the project, including a good estimate of the time of each stage • Does not consider time variations that can have a great impact on completion time of a complex project • When critical path tasks are shortened, the entire network must be recalculated	

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
	Bauer J, Duffy G, Westcott R, editors. The quality improvement handbook, Improvement tools. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2006. p. 109-48. Mind Tools Ltd. Critical path analysis. 2009. Available at: http://www.mindtools.com/critpath.html. Accessed August 24, 2009. Mycoted. Creativity and innovation techniques. 2009. Available at: http://www.mycoted.com/Category:Creativity_Techniques. Accessed August 24, 2009.	Shows the required order of tasks in a project or process, the best schedule for the entire project, and potential scheduling and resource problems and their solutions. It lets you calculate the "critical path" of the project. This is the flow of critical steps where delays will affect the timing of the entire project and where addition of resources can speed up the project. The purpose of CPM is to permit you to recognize, which activities lay on the 'critical path'—i.e. those for which any setback or rushing will affect the overall time for the project. This will assist you in managing the collection of tasks to accomplish fixed time targets overall. Used: • In scheduling projects • When scheduling and monitoring tasks within a complex project or process with interrelated tasks and resources • When you know the steps of a project or process, their sequence, and how long each step takes • When project schedule is critical, with serious consequences for completing late or significant advantage to	**"events."** An event marks the beginning or end of a task. Thus, events are nodes that separate tasks. 5. **Look for three common problem situations** and redraw them using "dummies" or extra events. A dummy is an arrow drawn with dotted lines used to separate tasks that would otherwise start and stop with the same events or to show logical sequence. Dummies are not real tasks. 6. **Label all events** in sequence with numbers. 7. Determine task times. 8. **Determine the "critical path,"** the longest path from beginning to end. 9. Calculate the earliest start, earliest finish, latest start, and latest finish times for each event. 11. **Calculate slack times** for each task and for the entire project. Total slack is the time a job could be postponed without delaying the project schedule. Total slack = LS – ES = LF – EF Free slack is the time a task could be postponed without affecting the		

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		completing early • To develop product improvement plans and follow-up activities	early start of any job following it. Free slack = the earliest ES of all tasks immediately following this one – EF Expertise: 1 Resources: Detailed knowledge of project being planned and all its stages		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
Critical-To-Quality Analysis	Tague N. The tools. In: O'Mara P, editor. The quality toolbox. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2005. p. 93-521.	A critical-to-quality (CTQ) analysis is a way of studying the flowchart of a process to identify quality features or characteristics most important to the customer and to find problems. The analysis studies inputs and outputs and identifies the steps that influence the quality of process outputs. Used: • When identifying the quality features or characteristics most important to the customer • When drawing a detailed flowchart of a process, to be sure that steps critical to achieving quality are included • After flowcharting a process, to identify problems and their potential causes • Whenever looking for opportunities for improvement in a process	1. Obtain or draw a detailed flowchart of the process. 2. **Study the output side of the flowchart** and answer who, what, when, where, and how. Use customer input to answer the when and how questions. Write the answers to these questions on the flowchart, using whatever symbols your group finds meaningful. Common markings are a box or oval for who, an arrow for where, words on the arrow for what, diamonds or circles for when and how. 3. **Look at the input side of your flowchart** and answer who, what, when, where, and how. Write the answers to these questions on the flowchart, using your own symbols. 4. For each output, **list your customer's needs**. Again, use customer input to answer these questions. Evaluate whether the output meets those needs. 5. For each input, **list your needs as a customer**. Evaluate whether the input meets your needs.	Cons: • Need to have a flowchart of the process in order to use	

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
			6. Find critical-to-quality steps. Steps where the quality of output can be affected: hurt or helped Steps where an input determines what happens next in the process Steps where you can measure whether inputs or outputs are meeting needs Mark or color these steps so they stand out. 7. **Study these critical-to-quality steps** to identify problems in your process. Expertise: 1 Resources: sticky notes, flip chart		

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Cross-functional Flowchart (Also called: cross functional diagram, "swim lane" flowchart, swim lane process mapping, deployment flowchart, down-across flowchart, process responsibility diagram, people-process chart, activity diagram)	Eitel D, McKniff S, Johnson D. Using future state design to create an EDIS and dashboard. 2007 Society for Health Systems Conference; 2007; New Orleans, LA; 2007. Lighter D. Process orientation in health care quality. In: Moore C, editor. Quality management in health care: principles and methods. 2 ed. Sudbury, MA: Jones and Bartlett Publishers; 2004. p. 43-101. George M, Rowlands D, Price M, et al. Value stream mapping and process flow tools. The lean six sigma pocket toolbook. New York: McGraw–Hill; 2005. p. 33-54. Lepley C. Simulation software: Engineer processes before reengineering. J Nurs Adm 2001 Jul-Aug;31(7-8):377-85. Tague N. The tools. In: O'Mara P, editor. The quality toolbox. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2005. p. 93-521.	A cross-functional flowchart is a more detailed flowchart that shows who (a person or group) performs each step in the process. It emphasizes the "who" in "who does what." Identifies who in the organization is required to implement a process. Can also be useful in identifying individuals or departments in the organization that are responsible for particular procedures. A Swim-Lane Flowchart emphasizes the "who" in "who does what." It makes it easy to study handoffs between people and/or work groups in a process. A swim-lane flowchart is especially useful with administrative (service) processes. A deployment flowchart is a detailed flowchart that also shows who (which person or group) performs each step. Cross-functional flowcharts describe the activities performed in a process as well as who performs each activity and which functional department they belong to. Swimlane diagrams highlight the relevant variables—who, what, and when—in a simple notation that requires little or	1. **Define the boundaries** of the process to be modeled, especially the start and end points. Both start and end points should be well-defined outputs or events. 2. Determine all individuals and departments (aka players) involved in the process. 3. **Construct the flowchart graphically** (usually done on a flipchart) by creating swim lanes (rows) or columns that correspond with the organizational units involved, preferably in such a sequence that players in close cooperation are located next to each other. 4. **Identify all activities** that are carried out in the process and write them down on sticky notes. 5. Starting at the beginning of the process, place the card or note with the first step of the process in the column (or row) of the player responsible for that step. Place the	Pros: • Identifies person who acts on each activity step or decision • Illuminates interdisciplinary handoffs • Software available • Identifies WHO does the work, not just what gets done • Demonstrates whether the flow is logical or involves a lot of back-and-forth between different units • Enables staff to easily visualize roles • Allows you to analyze when responsibilities in the process shift • Can denote external players in the process Cons: • Initially more challenging to create than standard flowchart • Time intensive • Need more of a skill set in subject matter and software ø	Johnson K, FitzHenry F. Case report: Activity diagrams for integrating electronic prescribing tools into clinical workflow. J Am Med Inform Assoc 2006 Jul-Aug;13(4):391-5.

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
	Andersen B, Fagerhaug T, Henriksen B, et al. Creating a cross-functional flowchart. In: O'Mara P, editor. Mapping Work Processes. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2008. p. 61-8. Sharp A, McDermott P. Process workflow models: The essentials. Workflow Modeling: Tools for Process Improvement and Applications Development. 2nd ed. Boston: Artech House; 2009. p. 201-31. Andersen B. Understanding your current business processes. In: O'Mara P, editor. Business process improvement toolbox. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2007. p. 27-63.	no training to understand. Because they specifically show the actors who are involved in the process, a higher level of involvement and buy-in is likely. The point is that when we ID processes, we have to focus on "what," but when we seek to understand processes, we need to factor in the "who, how, and when" as well. Swimlane diagrams are intended to show an entire business process from beginning to end and can be used both to understand the as-is workflow and to design and depict the to-be workflow. They can show a process at any level, from a very high-level view, depicting only the points of involvement by the actors (participants in the process), down to one showing each individual task. A cross-functional flowchart shows who performs the activities and which functional department they belong to—from which the name arises. Used: • To identify who in an organization is required to implement a process or achieve a certain task • To identify individuals or departments in an organization that are	second step a little farther along, to indicate later time sequence, opposite that step's key player. Continue to place all steps opposite the person or group responsible. Place them as though along a timeline, with time moving away from the names. If two steps happen simultaneously or the sequence is unimportant place the cards or notes at equal distances along the timeline. 6. **Draw arrows** between cards to show the flow of the process. Note: Some process steps involve two players: "Joe telephones Sally." For these, make a second card to place opposite the second name. Write the action from the point of view of the second player: "Sally receives phone call." 1. Define the major steps in the process. Create labeled boxes for each step. 2. Determine all individuals and departments involved in the process.		

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		responsible for particular processes • To study handoffs between people and/or work groups in a process • To analyze administrative (service) processes • When several different individuals or groups are involved in a process at different stages • When trying to understand or communicate responsibilities • When identifying supplier-customer relationships, internal or external • When studying how sequential or parallel steps affect cycle time • When allocating and tracking responsibilities on a project	3. Place the individuals and/or departments across the top of the chart design page. 4. Place the tasks in order below the individual /department responsible for the task. 5. Connect the tasks in sequence. 1. Identify the different people or job functions involved in the process. List them down the left side or across the top of a flip chart or whiteboard. 2. Brainstorm the steps in the process and write them on sticky notes. 3. Work through each step in order, placing the notes in the appropriate swim-lane. 4. Use the result to spark discussions on how to improve workflow. 1. Begin with steps 1, 2, and 3 of the basic procedure. 2. On a flipchart page or newsprint, list all players (individuals or groups) involved in the process. List them across the top or down the left side, whichever is the narrower dimension of the paper. Draw lines between each,		

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			extending the full dimension of the paper. 3. Starting at the beginning of the process, place the card or note with the first step of the process in the column (or row) of the layer responsible for that step. Place the second step a little farther along, to indicate later time sequence, opposite that step's key player. Continue to place all steps opposite the person or group responsible. Place them as though along a timeline, with time moving away from the names. If two steps happen simultaneously or the sequence is unimportant place the cards or notes at equal distances along the timeline. 4. Some process steps involve two players: "Joe telephones Sally." For these, make a second card to place opposite the second name. Write the action from the point of view of the second player: "Sally receives phone call." 5. Draw arrows between cards to show the flow of the process. 6. (Optional) In the		

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			column (or row) labeled "Actual Time," write opposite each step how long that step currently requires. In the column (or row_ labeled "Theoretical Time," write opposite each step how long it should take in an ideal process. The theoretical time for a step that does not add value should be zero. 7. Review the flowchart with others involved in the process (workers, supervisors, suppliers, customers) to see if they agree that the process is drawn. 1. Define the boundaries of the process to be modeled, especially the start and end points. Both start and end points should be well-defined outputs or events. 2. Typically starting from the end point, identify the activities that are carried out in the process, along with important outputs, periods of waiting, and so on. For new processes, we strongly advise starting from the end point. However, when reengineering old processes, we often start at the beginning of		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
			the process. You should, however, always keep the final outcome of the process in mind, to ensure a customer-oriented process. 3. For each of the activities in the process, determine which organizational unit is in charge of executing it. 4. Construct the flowchart graphically by creating swim lanes or columns that correspond with the organizational units involved, preferably in such a sequence that units in close cooperation are located next to each other. 5. Continue by placing items in sequence and in the proper swim lanes, from the end of the process working backward. In cases of decision points or places where the process branches out, try to orient the diagram so that activities flow in the most logical direction, that is, from left to right and top to bottom. 1. Define the boundaries for the business process to be modeled, especially the start and end points. Both should		

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			be well-defined outputs or events. 2. Starting from the end point, identify the activities carried out in the process, along with important outputs generated, periods of waiting, and so on. 3. For each of the items in the process, determine which organizational unit is in charge of executing the item. 4. Construct the flowchart graphically by creating swim lanes or columns that correspond with the organizational units involved, preferably in such a sequence that units with close cooperation are located next to each other. 5. Continue by placing items in the correct sequence and in the correct swim lane, moving from the end of the process backward. In cases of decision points or places where the process branches out, try to orient the diagram so that activities flow in the most suitable direction, that is, from left to right and top to bottom. 6. In cases of disagreement in the		

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			modeling team, take time to resolve any issues so that the final model truly reflects a common understanding. Remember that such disagreements often represent good opportunities for clarifying potential conflicts or misunderstandings. 7. When the team is satisfied that the most important elements of the process have been captured and placed in the correct sequence, it is a good idea to redraw the flowchart to increase readability. Expertise: 1 Resources: sticky notes, flip chart		

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Cycle Time Chart	Tague N. The tools. In: O'Mara P, editor. The quality toolbox. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2005. p. 93-521.	A cycle time chart is a graph that visually shows how much time is spent at each step of a process. Often it also shows associated costs and/or whether the steps are value-adding or non-value-adding. Used: • When studying a process to reduce its cycle time • When analyzing or communicating cycle time of "as-is" or "should-be" processes • After improving a process, to analyze or communicate the new cycle time	1. **Develop or obtain a detailed flowchart** or deployment flowchart of the process. Number each step sequentially. 2. **Determine how much time each step actually takes**. Add the times for all steps to determine the total cycle time for the process. 3. **Decide what information**, in addition to cycle time, you wish to include on your graph. Some possibilities are: cost for each step, cumulative cost, and whether each step is value-or non-value adding. Collect or assemble the information. 4. **Draw a graph** with the x-axis representing time. Determine the scale needed so that the full line equals the total cycle time. Using that scale, mark off distances to represent the cycle times of each step, starting with step 1 on the left. Label each space with the step number. 5. **Draw bars** for each step. Choose a method based on what additional information you wish to show. To show only cycle time: Draw bars for each step		

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			that are all the same height and as wide as the x-axis distance you marked off. For waits or delays, do not draw a bar. To show whether a step is value-or non-value-adding: Draw bars for value-adding steps above the line. Draw bars for non-value-adding steps below the line. Or, shade or color each bar to indicate real value-adding, organizational value-adding, and non-value-adding activities. Or use both methods. Again, for waits or delays, do not draw a bar. To show each step's cost: Scale the y-axis so that the top of its range is slightly larger than the highest cost. For each step, draw a bar with the height representing its cost. You may shade or color each bar to indicate the value-added category. This method and the next one create cost-cycle time charts. To show cumulative cost: Scale the y-axis so that the top of its range is slightly larger than the total cost. For step one, draw a vertical line at the right side of its space, representing		

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			step one's cost. Draw a line between the origin and the top of that line. For step two, draw a vertical line at the right side of its space, representing the sum of the costs for step one and step two. Draw a line across the top of that space, connecting the tops of the first vertical line and the second one. Continue each step of the process. You may shade or color each bar to indicate the value-added category. 6. **Write clarifying information** on the chart: cycle time for each step, total cycle time, actual costs, or any other information you think is necessary to communicate clearly. Expertise: 1 Resources: flowchart of process, stopwatch		

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Decision Action Diagrams (DAD) (Also called: information flow diagrams)	Stanton N, Salmon P, Walker G, et al. Process charting methods. Human factors methods: a practical guide for engineering and design. Great Britain: Ashgate; 2005. p. 109-37.	Decision action diagrams (DADs), also known as information flow diagrams, are used to graphically depict a scenario process in terms of the decisions required and actions to be performed by the operator involved in the activity. Decisions are represented by diamonds and each decision option available to the system operator is represented by exit lines. In their simplest form, the decision options are usually 'Yes' or 'No', however depending upon the complexity of the task and system, multiple options can also be represented. The DAD output diagram should display all of the possible outcomes at each task step in a process. Used: • To evaluate existing systems or to inform the design of system's and procedures	1. **Define the task or scenario under analysis**. Firstly, the scenario(s) under analysis should be clearly defined. DAD analysis can be used to analyze activity in existing systems or system design concepts. 2. **Data collection**. In order to construct a DAD, the analyst(s) must obtain sufficient data regarding the task or scenario under analysis. It is recommended that traditional HF data collection methods, such as observational study, interviews and questionnaires, are used for this purpose. However, if the analysis is based upon a design concept, then storyboards can be used to depict the scenario(s) under analysis. 3. **Conduct a task analysis**. Once the data collection phase is completed, a detailed task analysis should be conducted for the scenario under analysis. The type of task analysis is determined by the analyst(s), and in some cases, a task list	Pros: • A DAD can be used to depict the possible options that an operator faces during each task step in a scenario. This information can be used to inform the design of the system or procedures i.e. task steps that have multiple options associated with them can be redesigned • DADs are relatively easy to construct and require little training • DADs could potentially be used for error prediction purposed Cons: • In their current form. DADs do not cater for the cognitive component of task decisions • It would be very difficult to model parallel activity using DADs • DADs do not cater for processes involving teams. Constructing a team DAD would appear to be extremely difficult • It appears that a HTA for the task or scenario under analysis would be sufficient. A DAD output is very similar to the plans depicted in a HTA. • For large, complex tasks, the DAD would be difficult and time consuming to construct • The initial data collection phase involved in the DAD procedure adds a considerable amount of time	

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			will suffice. However, it is recommended that when constructing a DAD, a hierarchical task analysis (HTA) for the scenario under analysis is conducted. 4. **Construct DAD**. Once the task or scenario under analysis is fully understood, the DAD can be constructed. This process should begin with the first decision available to the operator of the system. Each possible outcome or action associated with the decision should be represented with an exit line from the decision diamond. Each resultant action and outcome for each of the possible decision exit lines should be specified. This process should be repeated for each task step until all of the possible decision outcomes for each task have been exhausted. Expertise: 1 Resources: none	to the analysis • Reliability and validity data for the method is sparse	

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Decision Matrix (Also called: Pugh matrix, decision grid, selection matrix or grid, problem matrix, problem selection matrix, opportunity analysis, solution matrix, criteria rating form, criteria-based matrix, prioritization matrix)	American Society for Quality. Evaluation and decisionmaking tools: Decision matrix. 2009. Available at: http://www.asq.org/learn-about-quality/decisionmaking-tools/overview/decision-matrix.html. Accessed July 2, 2009. Latino RJ. Opportunity analysis (OA): The modified approach. Patient safety: the PROACT® root cause analysis approach. Boca Raton, FL: CRC Press; 2009. p. 41-56. Tague N. The tools. In: O'Mara P, editor. The quality toolbox. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2005. p. 93-521.	A decision matrix evaluates and prioritizes a list of options. The team first establishes a list of weighted criteria and then evaluates each option against those criteria. This is a variation of the L-shaped matrix. Used: • When a list of options must be narrowed to one choice. • When the decision must be made on the basis of several criteria. • After the list of options has been reduced to a manageable number by list reduction. • To make a legitimate business case to analyze one event versus another • To focus the organization on what the most significant events are • When one improvement opportunity or problem must be selected to work on • When only one solution or problem-solving approach can be implemented • When only one new product can be developed	1. **Brainstorm** evaluation criteria appropriate to situation. 2. **Discuss and refine the list** of criteria. Reduce the list to the most important. 3. **Assign a relative weight** to each criterion based on how important that criterion is to the situation. 4. **Draw an L-shaped matrix**. Write criteria and their weights as labels along one edge and list of options along the other edge. 5. **Evaluate each choice** against criteria. 6. **Multiply each option's rating by the weight**. Add the points for each option. The option with the highest score will not necessarily be the one to choose, but the relative scores can generate meaningful discussion and lead the team toward consensus. 1. Perform preparatory work 2. Collect the data 3. Summarize and encode results 4. Calculate loss 5. Determine the "significant few" 6. Validate results 7. Issue a report	Pros: • Identifies which event is most significant or costly • Assesses all events and their individual impact on overall performance • Can be used to compare opinions Cons: • Some guessing and assuming involved	McCray M. How to get paid for the services you provide. 2007 Society for Health Systems Conference; 2007; New Orleans, LA; 2007.

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
			*Process above can be described in more detail Expertise: 1 Resources: none		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
Decision Tree (Also called: decision process flowchart, logic diagram)	Tague N. The tools. In: O'Mara P, editor. The quality toolbox. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2005. p. 93-521. Mind Tools Ltd. Decision tree. 2009. Available at: http://www.mindtools.com/dectree.html Accessed August 24, 2009.	A decision tree is a sequenced set of questions that lead to a correct decision or problem solution. It is a specialized tree diagram, but often it reads like a flow diagram. Typically, the tree is developed by people with expert knowledge of situations that are likely to occur repeatedly. Later, the tree is used by people without specialized knowledge to make decisions quickly without help. Decision Trees are useful tools for helping you to choose between several courses of action. They provide a highly effective structure within which you can explore options, and investigate the possible outcomes of choosing those options. They also help you to form a balanced picture of the risks and rewards associated with each possible course of action. This makes them particularly useful for choosing between different strategies, projects or investment opportunities, particularly when your resources are limited. Used: • When a situation requiring a decision or problem solution will arise	1. You start a Decision Tree with a DECISION THAT YOU NEED TO MAKE or a problem needing to be solved. Write the decision or problem on a sticky note and place it on the left hand side of a large piece of paper, half way down the page. 2. BRAINSTORM QUESTIONS that must be answered to reach the correct decision or answer to the problem. For each question, note what the possible answers are. Usually, these will be yes-no or a small set of choices. Write each question and its answers on a note and place it on the work surface. Let sequence guide you if that is helpful, but don't be too concerned about correct order yet. 3. DECIDE WHETHER THE QUESTIONS MUST BE ASKED IN A PARTICULAR SEQUENCE. If not, choose an efficient order. Sequence the questions by arranging the cards on the work surface. Show the link between an answer and the next question with an arrow. 4. REVIEW THE TREE	Pros: • Visually lays out your options Cons: • Need in depth and detailed knowledge of the situation involving the decision or problem	Gabrielson S, Schryver M, Morrey M. Creating a patient centered access system. 2007 Society for Health Systems Conference

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
		repeatedly • When the thought process for making the decision is known and can be laid out as a series of questions • Typical applications of decision trees include troubleshooting, emergency response, and documenting procedures that are complex, critical, or seldom used	for missing questions or answers. Review the questions to be sure they will be clearly understood and correctly answered by others. 5. TEST THE TREE. Create scenarios that reflect a range of different situations, and work through the tree for each one. Modify the tree if any problems are found. 6. Give people without expert knowledge the scenarios and ASK THEM TO USE THE TREE to make decisions. If they do not reach the correct decision, identify the question(s) where the error occurred and modify the tree. 1. Define the kind of situation in which the decision tree will be used. Develop a statement of the decision to be made or problem to be solved. Write it on a sticky note and place it at the far left of the work surface. 2. Brainstorm questions that must be answered to reach the correct decision. For each question, note what the possible answers are.		

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			Usually, these will be yes-no or a small set of choices. Write each question and its answers on a note and place it on the work surface. Let sequence guide you if that is helpful, but don't be too concerned about correct order yet. 3. Decide whether the questions must be asked in a particular sequence. If not, choose an efficient order. Sequence the questions by arranging the cards on the work surface. Show the link between an answer and the next question with an arrow. 4. Review the tree for missing questions or answers. Review the questions to be sure they will be clearly understood and correctly answered by others. 5. Test the tree. Create scenarios that reflect a range of different situations, and work through the tree for each one. Modify the tree if any problems are found. 6. Give people without expert knowledge the scenarios and ask them to use the tree to make decisions. If they do not		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
			reach the correct decision, identify the question(s) where the error occurred and modify the tree. 1. You start a Decision Tree with a decision that you need to make. Draw a small square to represent this on the left hand side of a large piece of paper, half way down the page. 2. From this box draw out lines towards the right for each possible solution, and write a short description of the solution along the line. Keep the lines apart as far as possible so that you can expand your thoughts. 3. At the end of each line, consider the results. If the result of taking that decision is uncertain, draw a small circle. If the result is another decision that you need to make, draw another square. Squares represent decisions, and circles represent uncertain outcomes. Write the decision or factor above the square or circle. If you have completed the solution at the end of the line, just leave it blank.		

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			4. Starting from the new decision squares on your diagram, draw out lines representing the options that you could select. From the circles draw lines representing possible outcomes. Again make a brief note on the line saying what it means. Keep on doing this until you have drawn out as many of the possible outcomes and decisions as you can see leading on from the original decisions. Expertise: 1 Resources: sticky notes, flip chart		

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Event Tree Analysis (ETA)	Stanton N, Salmon P, Walker G, et al. Process charting methods. Human factors methods: a practical guide for engineering and design. Great Britain: Ashgate; 2005. p. 109-37.	Event tree analysis is a task analysis method that uses tree-like diagrams to represent possible outcomes associated with operator tasks steps in a scenario. Originally used in system reliability analysis, event tree analysis can also be applied to human operations to investigate possible actions and their consequences. A typical event tree output comprises a tree-like diagram consisting of nodes (representing task steps) and exit lines (representing the possible outcomes). Used: • To depict task sequences and their possible outcomes • To identify error potential within a system • To model team-based tasks	1. **Define scenario(s) under analysis**. Firstly, the scenario(s) under analysis should be clearly defined. Event tree analysis can be used to analyze activity in existing systems or system design concepts. The task under analysis should be clearly defined. 2. **Data collection phase**. The next step involves collecting the data required to construct the event tree diagram. If the event tree analysis is focused upon an operational system, then data regarding the scenario under analysis should be collected. It is recommended that traditional data collection methods, such as observational study, interviews and questionnaires, are used for this purpose. However, if the analysis is based upon a design concept, then storyboards can be used to depict the scenario(s) under analysis. 3. **Draw up task list**. Once the scenario under analysis is defined clearly and sufficient data is	Pros: • Event tree analysis can be used to highlight a sequence of tasks steps and their associated consequences • Event tree analysis can be used to highlight error potential and error paths throughout a system • The method can be used in the early design life cycle to highlight task steps that may become problematic (multiple associated response options) and also those task steps that have highly critical consequences • If used correctly, the method could potentially depict anything that could possibly go wrong in a system • Event tree analysis is a relatively easy method that requires little training • Event tree analysis has been used extensively in PSA/HRA • Cons: • For large, complex tasks, the event tree diagram can become very large and complex • Can be time consuming in its application • Task steps are often not explained in the output	

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			collected, a comprehensive task list should be created. The component task steps required for effective task performance should be specified in sequence. This initial task list should be representative of standard error-free performance of the task or scenario under analysis. It may be useful to consult with subject-matter experts (SMEs) during this process. 4. **Determine possible actions for each task step**. Once the task list is created, the analyst should then describe every possible action associated with each task step in the task list. It may be useful to consult with SMEs during this process. Each task step should be broken down into the human or system operations required and any controls or interface elements used should also be noted. Every possible action associated with each task step should be recorded. 5. **Determine consequences associated with each**		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
			possible action. Next, the analyst should take each action specified in step 4 and record the associated consequences. 6. **Construct event tree**. Once steps 4 and 5 are complete, the analyst can begin to construct the event tree diagram. The event tree should depict all possible actions and their associated consequences. Expertise: 2 Resources: none		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
Failure Modes and Effects Analysis (FMEA) (Also called: potential failure modes and effects analysis; failure modes, effects and criticality analysis (FMECA))	Latino RJ. Basic failure mode and effects analysis: The traditional approach. Patient SAFETY: THE PROACT® root cause analysis approach. Boca Raton, FL: CRC Press; 2009. p. 31-9. American Society for Quality. Process Analysis Tools: Failure Modes and Effects Analysis (FMEA). 2009. Available at: [http://www.asq.org/learn-about-quality/process-analysis-tools/overview/fmea.html. Accessed July 22](http://www.asq.org/learn-about-quality/process-analysis-tools/overview/fmea.html), 2009. Lighter D. Process orientation in health care quality. In: Moore C, editor. Quality management in health care: principles and methods. 2 ed. Sudbury, MA: Jones and Bartlett Publishers; 2004. p. 43-101. George M, Rowlands D, Price M, et al. Selecting and testing solutions. The lean six sigma pocket toolbook. New York: McGraw–Hill; 2005. p. 253-76. Tague N. The tools. In: O'Mara P, editor. The	Failure modes and effects analysis (FMEA) is a step-by-step approach for identifying all possible failure events that *could* occur within a given system and what the associated effects would be if it were to occur. This technique determines what failure events *could* occur within a given system and what the associated effects would be if it were to occur. Failure modes and effects analysis (FMEA) is a step-by-step approach for identifying all possible failures in a design, a manufacturing or assembly process, or a product or service, and the potential consequences of those failures. Applied to existing or proposed processes to anticipate errors and to design systems to avoid mistakes. Used: • When a process, product or service is being designed or redesigned, after quality function deployment • When an existing process, product or service is being applied in a new way • Before developing control	1. Identify the scope of the system 2. Define an unacceptable risk in the system 3. Organize the analysis team 4. Establish severity ratings 5. Establish probability ratings 6. Establish detectability ratings 7. Complete FMEA spreadsheet a. Define subsystem b. Define event c. Define mode 8. Develop corrective action plan 1. ASSEMBLE A CROSS-FUNCTIONAL TEAM of people with diverse knowledge about the process, product or service and customer needs. Functions often included are: design, manufacturing, quality, testing, reliability, maintenance, purchasing (and suppliers), sales, marketing (and customers) and customer service. 2. IDENTIFY THE SCOPE of the FMEA. Is it for concept, system, design, process or service? What are the	Pros: • Quantifies the three most important attributes of a failure mode • Ability to gain an estimate of the importance of each factor in the failure mode provides a powerful tool for prioritizing safety and error issues • Can be done in a word processing or spreadsheet program to simplify analysis and data recording • Can anticipate and eliminate potential causes of errors Cons: • Can be difficult and time consuming • Not a foolproof method for determining highest risk and priority for action	Roberts L, Johnson C, Shanmugam R, et al. Computer simulation and six-sigma tools applied to process improvement in an emergency department. 17th Annual Society for Health Systems Management Engineering Forum 2005; Dallas, TX; 2005. Latino RJ. Case studies. Patient safety: the PROACT® root cause analysis approach. Boca Raton, FL: CRC Press; 2009. p. 171-87. Wetterneck TB, Skibinski KA, Roberts TL, et al. Using failure mode and effects analysis to plan implementation of smart iv pump technology. Am J Health Syst Pharm 2006;63:1528-38.

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
	quality toolbox. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2005. p. 93-521. The Boeing Company. Advanced quality system tools. 1998. Available at: http://www.boeing.com/companyoffices/doingbiz/supplier/d1-9000-1.pdf. Accessed August 24, 2009.	plans for a new or modified process • When improvement goals are planned for an existing process, product or service • When analyzing failures of an existing process, product or service • Periodically throughout the life of the process, product or service • To anticipate errors • To avoid mistakes • To identify the ways in which a product, service, or process can fail • Estimate risk associated with specific failure causes • Prioritize the actions to reduce risk of failure • Evaluate design validation plan (product/service) or current control plan (process) • When designing new systems, products, and processes • When changing existing designs or processes • When carry-over designs are used in new applications • After system, product, or process functions are defined, but before beginning detailed final design • To understand the risks of a project • To understand the improvement implementation risks • To assess the	boundaries? How detailed should we be? Use flowcharts to identify the scope and to make sure every team member understands it in detail. (From here on, we'll use the word "scope" to mean the system, design, process or service that is the subject of your FMEA.) 3. FILL IN THE IDENTIFYING INFORMATION at the top of your FMEA form. Figure 1 shows a typical format. The remaining steps ask for information that will go into the columns of the form. 4. IDENTIFY THE FUNCTIONS OF YOUR SCOPE. Ask, "What is the purpose of this system, design, process or service? What do our customers expect it to do?" Name it with a verb followed by a noun. Usually you will break the scope into separate subsystems, items, parts, assemblies or process steps and identify the function of each. 5. For each function, IDENTIFY ALL THE WAYS FAILURE COULD HAPPEN. These are potential failure modes. If		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
		effectiveness of a Control Plan	necessary, go back and rewrite the function with more detail to be sure the failure modes show a loss of that function. 6. For each failure mode, IDENTIFY ALL THE CONSEQUENCES on the system, related systems, process, related processes, product, service, customer or regulations. These are potential effects of failure. Ask, "What does the customer experience because of this failure? What happens when this failure occurs?" 7. DETERMINE HOW SERIOUS EACH EFFECT IS. This is the severity rating, or S. Severity is usually rated on a scale from 1 to 10, where 1 is insignificant and 10 is catastrophic. If a failure mode has more than one effect, write on the FMEA table only the highest severity rating for that failure mode. 8. For each failure mode, DETERMINE ALL THE POTENTIAL ROOT CAUSES. Use tools classified as Root Cause/Risk Analysis, as well as the best knowledge and experience of the team. List all possible causes		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
			for each failure mode on the FMEA form. 9. For each cause, DETERMINE THE OCCURRENCE RATING, or O. This rating estimates the probability of failure occurring for that reason during the lifetime of your scope. Occurrence is usually rated on a scale from 1 to 10, where 1 is extremely unlikely and 10 is inevitable. On the FMEA table, list the occurrence rating for each cause. 10. For each cause, IDENTIFY CURRENT PROCESS CONTROLS. These are tests, procedures or mechanisms that you now have in place to keep failures from reaching the customer. These controls might prevent the cause from happening, reduce the likelihood that it will happen or detect failure after the cause has already happened but before the customer is affected. 11. For each control, DETERMINE THE DETECTION RATING, or D. This rating estimates how well the controls can detect either the cause or its		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
			failure mode after they have happened but before the customer is affected. Detection is usually rated on a scale from 1 to 10, where 1 means the control is absolutely certain to detect the problem and 10 means the control is certain not to detect the problem (or no control exists). On the FMEA table, list the detection rating for each cause. 12. (Optional for most industries) IS THIS FAILURE MODE ASSOCIATED WITH A CRITICAL CHARACTERISTIC? (Critical characteristics are measurements or indicators that reflect safety or compliance with government regulations and need special controls.) If so, a column labeled “Classification” receives a Y or N to show whether special controls are needed. Usually, critical characteristics have a severity of 9 or 10 and occurrence and detection ratings above 3. 13. CALCULATE THE RISK PRIORITY NUMBER, or RPN, which equals S × O × D. Also calculate Criticality		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
			by multiplying severity by occurrence, S × O. These numbers provide guidance for ranking potential failures in the order they should be addressed. 14. IDENTIFY RECOMMENDED ACTIONS. These actions may be design or process changes to lower severity or occurrence. They may be additional controls to improve detection. Also note who is responsible for the actions and target completion dates. 15. As actions are completed, NOTE RESULTS and the date on the FMEA form. Also, note new S, O or D ratings and new RPNs. 1. Assemble team with diverse knowledge of process, product or service. 2. Identify scope of the FMEA. 3. Fill in the identifying information at the top of your FMEA form. 4. Identify the function of your scope. 5. For each function, identify all the ways failure could happen. These are potential failure modes. 6. For each failure		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
			mode, identify all the consequences on the system, related systems, process, related processes, product, service, customer or regulations. 7. Determine how serious each effect or the severity rating (S). 8. For each failure mode, determine all the potential root causes. 9. For each cause, determine the occurrence rating (O). 10. For each cause, identify current process controls that may prevent the cause. 11. For each control, determine detection rating (D) 12. Is this failure mode associated with measurements or indicators that reflect safety or compliance with government regulations and need special controls? 13. Calculate the risk priority number (RPN), which equals S x O x D. 14. Identify recommended actions. 15. As actions are completed, note results, date, and new S, O, or D ratings and new RPNs. *FMEA template in ASQ		

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			1. Choose a high-risk process for review. Although quality improvement processes typically fall into any of three categories—high risk, high cost, or high volume—FMEA projects generally are classified as high risk of error. 2. Assemble a team of people who are familiar with or use the process regularly. 3. Create a flowchart of how the process works currently. If the process is new, skip this step and proceed to next step. 4. Create a flow chart that defines the optimum process (a PERT diagram may provide the best information). 5. Evaluate the process flowcharts to determine the location, type, and severity of failure modes, i.e., the potential failures that may occur at each step of the process. 6. For each failure mode, calculate a criticality index that helps prioritize action plans for change. The criticality index, also called a risk priority number, is the product		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
			of rankings for three parameters: severity ranking, occurrence ranking, and detection ranking. The criticality index for each failure mode can then be used to identify high priority items, with the highest scores receiving the highest priority. 7. Implement changes using the plan-do-study-act cycle. 8. Recalculate the criticality index for each failure mode after implementation of the improvement. Each failure mode should be re-evaluated because improvement in one part of a process may cause improvements in other parts of the process. 9. Optimize the process and make the changes part of the process. 1. Review the product, service or process. 2. Brainstorm then sort possible failure modes. 3. List one or more potential effects for each failure mode. 4. Assign ratings for severity and occurrence. 5. List current monitoring and controls for each failure then assign a detection rating to each.		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
			6. Calculate a risk priority number (RPN) for each effect by multiplying the three numbers (severity * occurrence * detection). 7. Use the RPNs to select high-priority failure modes. 8. Plan to reduce or eliminate the risk associated with high-priority failure modes. 9. Carry out the plans. Document actions taken. 10. Recompute RPN. Resources: none Expertise: 2		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
Fault Tree Analysis (FTA)	Tague N. The tools. In: O'Mara P, editor. The quality toolbox. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2005. p. 93-521. Stanton N, Salmon P, Walker G, et al. Process charting methods. Human factors methods: a practical guide for engineering and design. Great Britain: Ashgate; 2005. p. 109-37.	Fault tree analysis uses a tree diagram to study a specific failure of a system, process, or product. The failure may have already happened, or it may be potential. Working backward from the failure, all the ways in which situations or events can combine to lead to the failure are identified, back to fundamental events or root causes. When probabilities of each cause are known, the probability of failure can be calculated. The primary purpose of fault tree analysis is to identify changes that can reduce or eliminate the chance of failure. Fault trees are used to graphically represent system failures and their causes. A fault tree is a tree-like diagram, which defines the failure event and displays the possible causes in terms of hardware failure or human error. Typically the failure event or top event is placed at the top of the fault tree, and the contributing events are placed below. The fault tree is held together by AND and OR gates, which link contributory events together. An AND gate is used when more than one event causes a failure i.e. when multiple contributory factors are involved. The events placed directly underneath an AND	1. **Identify the system or process that will be examined**, including boundaries that will limit your analysis. Flow diagrams are useful here. 2. **Identify the type of failure** that will be analyzed. This may be either an actual event that has occurred (retrospective incident analysis) or an imaginary event (predictive analysis). Define it as narrowly and specifically as possible. This is called the top event. Draw a rectangle at the top of the diagram and write description of the failure in it. 3. **Identify events** that may be immediate causes of the top event. Write these events at the level below the event they cause. 4. For each event, **ask** "Is this a basic failure? Or can it be analyzed for its immediate causes?" If this event is a basic failure, draw a circle around it. If it can be analyzed for its own causes, draw a rectangle around it. 5. **Ask**, "how are these events related to the one they cause?" Use	Pros: • Fault trees are useful in that they define possible failure events and associated causes. This is especially useful when looking at failure events with multiple causes. • Fault tree type analysis has been used extensively in PSA • Could potentially be used both predicatively and retrospectively • Although most commonly used in the analysis of nuclear power plant events, the method is generic and can be applied in any domain • Fault trees can be used to highlight potential weak points in a system design concept • The method could be particularly useful in modeling team-based errors, where a failure event is caused by multiple events distributed across a team of personnel Cons: • When used in the analysis of large, complex systems, fault tree diagrams can quickly become large and complicated • To utilize the method quantitatively, a high level of training may be required • The use of fault trees as a predictive tool remains largely unexplored • There is little evidence of	

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
		gate must occur together for the failure event above to occur. An OR gate is used when the failure event could be caused by more than on e contributory event in isolation, but not together. The event above the OR gate may occur if any one of the events below the OR gate occurs. Used: • During design or redesign of a system, process, product, or service, to identify causes of a potential failure and look for ways to prevent that failure • After an accident, error, or other failure has occurred, to identify its causes and prevent future occurrences • Especially when the system is complicated, with multiple interrelated causes of failure • In probabilistic safety assessment (PSA) • At any stage in a system life cycle to predict failure events and their causes • For the retrospective analysis of incidents • For the prediction of failure in a particular scenario	gate symbols to show relationships. The lower-level events are the input events. The one they cause is the output event. 6. **Classify causes as AND/OR**. If two or more cause events contribute to the failure event, then they are classified as AND events. If two or more cause events are responsible for the failure even when they occur separately, then they are classified as OR events. 7. For each event that is not basic, **repeat steps** 3, 4, 5, and 6. Continue until all branches of the tree end in a basic or undeveloped event. 8. (Optional) To determine the mathematical probability of failure, **assign probabilities** to each of the basic events. Use Boolean algebra to calculate the probability of each higher-level event and the top event. FTA software makes the calculations easier. 9. **Analyze the tree** to understand the relations between the causes and to find ways to prevent failures. Use the gate relationships to find the most efficient ways to	their use outside of the nuclear power domain	

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
			reduce risk. Focus attention on the causes most likely to happen, using probabilities or your knowledge of the system. 1. Identify the system or process that will be examined, including boundaries that will limit your analysis. Flow diagrams are useful here. 2. Identify the type of failure that will be analyzed. Define it as narrowly and specifically as possible. This is called the top event. Draw a rectangle at the top of the diagram and write description of the failure in it. 3. Identify events that may be immediate causes of the top event. Write these events at the level below the event they cause. 4. For each event, ask "Is this a basic failure? Or can it be analyzed for its immediate causes?" If this event is a basic failure, draw a circle around it. If it can be analyzed for its own causes, draw a rectangle around it. 5. Ask, "how are these events related to the one they cause?" Use		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
			gate symbols to show relationships. The lower-level events are the input events. The one they cause is the output event. 6. For each event that is not basic, repeat steps 3, 4, and 5. Continue until all branches of the tree end in a basic or undeveloped event. 7. (Optional) To determine the mathematical probability of failure, assign probabilities to each of the basic events. Use Boolean algebra to calculate the probability of each higher-level event and the top event. FTA software makes the calculations easier. 8. Analyze the tree to understand the relations between the causes and to find ways to prevent failures. Use the gate relationships to find the most efficient ways to reduce risk. Focus attention on the causes most likely to happen, using probabilities or your knowledge of the system. 1. *Define failure event*. The failure or event under analysis should be defined first. This may be either an actual		

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			event that has occurred (retrospective incident analysis) or an imaginary event (predictive analysis). This event then becomes the top event in the fault tree. 2. *Determine the causes of failure event*. Once the failure event has been defined, the contributory causes associated with the event should be defined. The nature of the causes analyzed is dependent upon the focus of the analysis. Typically, human error and hardware failures are considered. 3. *AND/OR classification*. Once the cause(s) of the failure event are defined, the analysis proceeds with the AND or OR causal classification phase. Each contributory causes identified during step 2 of the analysis should be classified as either an AND or an OR event. If two or more contributory events contribute to the failure event, then they are classified as AND events. If two or more contributory events are responsible for the failure even when they		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
			occur separately, then they are classified as OR events. Steps 2 and 3 should be repeated until each of the initial causal events and associated causes are investigated and described fully. 4. *Construct fault tree diagrams*. Once all events and their causes have been defined fully, they should be put into the fault tree diagram. The fault tree should begin with the main failure or top event at the top of the diagram with its associated causes linked underneath as AND/OR events. The diagram should continue until all events and causes are exhausted fully. Expertise: 1 Resources: none		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
Flowchart (Also called: process map, process flowchart, process flow diagram, flow diagram, flow sheet)	The Hiser Group. Observe and analyse—Toolkit. 2006. Available at: http://www.hiser.com.au/the_hiser_element_toolkit/observe_and_analyse_-_toolkit.html. Accessed May 20, 2009. American Society for Quality. Process analysis tools: Flowchart. 2009. Available at: http://www.asq.org/learn-about-quality/process-analysis-tools/overview/flowchart.html. Accessed June 24, 2009. Victorian Quality Council. Process mapping: A guide for health service staff. 2007. Available at: http://www.iienet2.org/uploadedFiles/SHS_Community/Value Stream or Process Map(1).pdf. Accessed June 24, 2009. Beam J, Rhodes S. Survivor—ED island. 2007 Society for Health Systems Conference; 2007; New Orleans, LA; 2007. Eitel D, McKniff S, Johnson D. Using future state design to create an EDIS and dashboard. 2007 Society for Health	A technique to assist user interface designers to develop diagrams that help ensure that the design of the user interface matches the users' workflow. During design, users and designers use the workflow diagram to communicate clearly about what aspect of work is being considered. Flowcharts present the logical flow of information through a system in graphical or pictorial form, as well as show the relationships used and provided by processes within a system Involves developing a simple visual picture, or map, of a process. It is a relatively simple tool that can help an organization better understand how parts of the organization work, and assist with analyzing how it could work better. A diagram that uses graphical symbols to depict the flow of the steps in a process. Allows a critical examination of the various steps of the process and assists in the identification of unnecessary steps and inefficiencies in the process.	1. Define the process to be diagrammed. 2. **Discuss and decide on the boundaries** of your process: Where or when does the process start? Where or when does it end? Discuss and decide on the level of detail to be included in the diagram. 3. **Brainstorm the activities** that take place. Sequence is not important at this point, although thinking in sequence may help people remember all the steps. Note: Some useful questions to help identify all steps in the process: Who provides the input for this step? Who uses it? What is done with the input? What decisions are made while input is being used? What is the output to this step? Who uses it to do what? 4. (Optional) **Assign the proper symbols** (see table) to each step. 5. **Arrange the activities** in proper sequence and/or concurrence. 6. When all activities are included and everyone agrees that the sequence is correct, **draw arrows** to show	Pros: • Highlights areas for improvement • Gives user customer viewpoint • Explores the inter-relationships of the process and those within it • Clarifies responsibilities and ownership • Identifies how resources used • A lot of process mapping software available • Not difficult • Quickly identify some bottlenecks • Quickly identify variation between shifts and staff in key decision points • Identify areas where further data and analysis was needed • Illuminates decision points • Stimulates communication among participants and establishes a common understanding about the process • Uncovers steps that are redundant or misplaced • Basic steps for creating a process map are the same no matter what type of map you're creating • Depict flow and structure of actions involved in the task under analysis • Simple to learn and construct • Allow the analyst to observe how a task is undertaken • Provide the analyst with a	St. Mary's Outpatient Surgery Center. Colonoscopy prep workflow. Madison, WI; 2009. St. Mary's Outpatient Surgery Center. Scheduling protocol for anticoagulants. Madison, WI; 2009. Eckenrode S, Dunn K, Brice E. Improving patient flow with a redesigned nursing report process. 17th Annual Society for Health Systems Management Engineering Forum; 2005; Dallas, TX; 2005. Merryman B, Campbell C. Accelerating the ED admitting process. 17th Annual Society for Health Systems Management Engineering Forum; 2005; Dallas, TX; 2005. Taveras M. Increasing charge capture using scheduling techniques for a hospital-based ancillary service. 17th Annual Society for Health Systems Management Engineering Forum; 2005; Dallas, TX; 2005. Burdick T, Cochran J, Modena C, et al. Redesigning emergency

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	Systems Conference; 2007; New Orleans, LA; 2007. Coleman Associates. Patient visit mapping toolkit: A bird's eye view of the patient experience. 2007. Available at: [http://www.norc.org/6275/Module7/Patient Visit Mapping ToolKit 11.11.07 NRC PDF.pdf](http://www.norc.org/6275/Module7/Patient%20Visit%20Mapping%20ToolKit%2011.11.07%20NRC%20PDF.pdf). Accessed July 9, 2009. Kachhal S. Industrial engineering applications in health care systems. In: Salvendy G, editor. Handbook of industrial engineering: technology and operations management. 3rd ed. New York: John Wiley & Sons, Inc.; 2001. p. 737-50. University Research Co. LLC. Quality Assurance Project: Flowchart. 2008. Available at: http://www.qaproject.org/methods/resflowchart.html. Accessed July 28, 2009. Lighter D. Process orientation in health care quality. In: Moore C, editor. Quality management in health care: principles and methods. 2 ed. Sudbury,	A flowchart is a graphic representation of how a process works, showing, at a minimum, the sequence of steps. Several types of flowcharts exist: the most simple (*high level*), a detailed version (*detailed*), and one that also indicates the people involved in the steps (*deployment or matrix*). Process charts offer a systematic approach to describing and representing a task or scenario that is easy to follow and understand. Process charts are used to graphically represent separate steps or events that occur during the performance of a task. A flowchart is a picture of the separate steps of a process in sequential order. Elements that may be included are: sequence of actions, materials or services entering or leaving the process (inputs and outputs), decisions that must be made, people who become involved, time involved at each step, and/or process measurements. The process described can be anything: a manufacturing process, an administrative or service process, a project plan. Usually listed as one of the seven quality control	the flow of the process. 7. **Review the flowchart with others involved** in the process (workers, supervisors, suppliers, customers) to see if they agree that the process is drawn accurately. 1. Define the process to be diagrammed. 2. Discuss and decide on the boundaries of your process: Where or when does the process start? Where or when does it end? Discuss and decide on the level of detail to be included in the diagram. 3. Brainstorm the activities that take place. Sequence is not important at this point, although thinking in sequence may help people remember all the steps. 4. Arrange the activities in proper sequence. 5. When all activities are included and everyone agrees that the sequence is correct, draw arrows to show the flow of the process. 6. Review the flowchart with others involved in the process (workers, supervisors, suppliers, customers) to see if they agree that the process	simple, graphical reorientation of the task or scenario under analysis Cons: • Doesn't show value • Doesn't show time • Need to be very knowledgeable of the process • May need multiple views of process • Doesn't show who is doing each activity (however a cross-functional flowchart does) • Can be difficult to decide on level of detail and follow through on that decided level of detail • For large tasks, may become large and unwieldy • Do not take into account error, modeling only error-free performance • Limited amount of information can be represented • Only offer descriptive information • May require several sessions to complete	department care delivery focusing on patient safety. 2007 Society for Health Systems Conference; 2007; New Orleans, LA; 2007.

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
	MA: Jones and Bartlett Publishers; 2004. p. 43-101. George M, Rowlands D, Price M, et al. Value stream mapping and process flow tools. The lean six sigma pocket toolbook. New York: McGraw–Hill; 2005. p. 33-54. Stanton N, Salmon P, Walker G, et al. Process charting methods. Human factors methods: a practical guide for engineering and design. Great Britain: Ashgate; 2005. p. 109-37. Tague N. The tools. In: O'Mara P, editor. The quality toolbox. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2005. p. 93-521. Bauer J, Duffy G, Westcott R, editors. The quality improvement handbook, Improvement Tools. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2006. p. 109-48. The Boeing Company. Advanced quality system tools. 1998. Available at: http://www.boeing.com/companyoffices/doingbiz/s	tools, this is a generic tool that can be adapted for a wide variety of purposes. A flowchart is a graphic representation of the flow of a process. It is a useful way to examine how the various steps in a process relate to each other, to define the boundaries of the process, to verify and identify customer-supplier relationships in a process, to create common understanding of the process flow, to determine the current "best method" of performing the process, and to identify redundancy and unnecessary complexity. Used: • To develop understanding of how a process is done • To study a process for improvement • To communicate to others how a process is done • When better communication is needed between people involved with the same process • To document a process • When planning a project • To help clarify how things are currently working and how they could be improved • To find the key elements of a process • To identify appropriate team members	is drawn accurately. *Flowchart template in ASQ Decide on process and project aim, decide on scope of process, document current process, analyze existing process, determine action required and draw new process map, implement new process 1. Agree on purpose of flowchart and which format (high-level, detailed, deployment, matrix, etc.) is most appropriate. 2. Determine and agree on beginning and end points of the process to be flowcharted. 3. Identify the elements of the flowchart by asking a. Who provides the input for this step? Who uses it? b. What is done with the input? What decisions are made while input is being used? c. What is the output to this step? Who uses it to do what? 4. Review the first draft of the flowchart to see		

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	upplier/d1-9000-1.pdf. Accessed August 24, 2009. Iowa Foundation for Medical Care, Medicare Quality Improvement Organization for Iowa, Care IFfQH. Doctor's Office Quality—Information technology: Process mapping guidelines. 2008. Available at: http://www.ifqhc.org/provider/documents/process_mapping_guidelines.pdf. Accessed June 19, 2009.	• To identify who provides inputs or resources to whom • To establish important areas for monitoring or data collection • To identify areas for improvement or increased efficiency • To generate hypotheses about causes • To examine processes for the flow of patients, information, materials, clinical care, or combinations of these processes • To identify and communicate the steps in a work process • To identify areas that may be the source of a problem or determine improvement opportunities	whether the steps are in their logical order. Areas that are unclear can be represented with a cloud symbol, to be clarified later. 5. After a day or two, review the flowchart with the group to see if everyone is satisfied with the result. Ask others involved in the process if they feel it reflects what they do. 1. List steps involved in process. 2. Determine order in which steps occur. 3. Separate steps into operations and procedures. 4. Decide where decision points occur and place the decision diamond shapes accordingly. 5. Connect shapes with appropriate connectors. 1. Review the process being studied and its boundaries as defined for your project. 2. Identify the type of chart you want to create. 3. Have participants identify the steps in the process. Write each step on a sticky note or card using the appropriate symbol.		

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			4. Working as a team, arrange the steps in order. 5. Discuss the results. Does it match reality as you know it? Adjust as needed. 6. When done, number the tasks sequentially through the most direct route, then number off-line tasks. 7. Transfer completed map to paper or computer. 1. Obtain sufficient data regarding the scenario under analysis using various forms of data collection (observations, interviews, questionnaires, etc.). 2. Create a comprehensive list of the task steps involved in the scenario and put into chronological order. 3. Classify each step into one of the process chart behaviors; Operation, Transportation, Storage, Inspection, Delay or combined operation. 4. Construct the process chart by linking each operation, transportation, storage, inspection, delay or combined operation in a vertical chart.		

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			1. Select the process to chart. 2. Determine whether to develop a high=level or detailed flowchart. 3. Define the boundaries of the selected process. 4. Identify the "start block" and place it on the top left corner of the page. 5. Identify the "finish block," or the end point, and place it on the bottom right corner of the page. 6. Try to identify the easiest and most efficient way to go from the "start block" to the "finish block." Though this step isn't absolutely necessary, it does make it easier to do the next step. 7. Document each step in sequence, starting with the first (or last) step. 8. Use the appropriate symbol for each step. 9. Be sure to chart how the work is actually done, not how it is supposed to be done. 10. At each decision point, choose one branch and continue flowcharting that section of the process. 11. If a segment of the process is unfamiliar to everyone, make a note		

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			and continue flowcharting. 12. Repeat steps 6, 7, and 8 until that section of the process is complete. Go back and flowchart the other branches from the decision symbols. 13. Identify all the areas that hinder your process or add little or no value. 14. After the flowchart is accurate and complete, analyze it. 15. Build a new flowchart that corrects the problems you identified in the previous step. Expertise: 1 Resources: sticky notes, flip chart		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
Focus Group (Also called: Discussion Forum)	Tague N. The tools. In: O'Mara P, editor. The quality toolbox. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2005. p. 93-521. George M, Rowlands D, Price M, et al. Voice of the customer. The lean six sigma pocket toolbook. New York: McGraw–Hill; 2005. p. 55-68.	A focus group brings together up to a dozen people to discuss their attitudes and concerns about a subject. Used: • To clarify and define customer needs • To gain insights into the prioritization of needs • To test concepts and get feedback • As prework for a survey or interviews to identify topics of critical interest to customers • As follow-up to customer interviews as a way to verify lessons or information learned	1. Identify the number and target size of the focus group. 2. **Identify the participants**. Your options are to mix representatives of different customer segments, or focus on a specific segment or on people known to have an interest in the topic. 3. **Develop the questions**. Do a pilot to test the ease of gathering and analyzing data. 4. **Conduct the focus group**. This may be harder than you think if there is little experience in doing focus groups. 5. After the focus group, transcribe the comments. 6. Select the appropriate follow-up action. Expertise: 1 Resources: none	Pros: • Allows for more creativity and open-ended answers than surveys but isn't a s time-consuming as interviews • Allows participants to play off each other's ideas • Lets you observe people interacting with physical items (products, prototypes, marketing materials, etc.), which you can't get from surveys	Wilson R, Purves I, Smith D. Utilisation of computerised clinical guidance in general practice consultations. In: Hasman A, Blobel B, Dudeck J, Engelbrecht R, et al editors. Medical Infobahn for Europe: Proceedings of MIE2000 and GMDS2000. The Netherlands: IOS Press; 2000. p. 229-33.

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
Force-field Analysis	University Research Co. LLC. Quality Assurance Project: Force-field analysis. 2008. Available at: http://www.qaproject.org/methods/resforcefield.html. Accessed July 28, 2009. Tague N. The tools. In: O'Mara P, editor. The quality toolbox. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2005. p. 93-521. Bauer J, Duffy G, Westcott R, editors. The quality improvement handbook, Improvement Tools. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2006. p. 109-48. Mind Tools Ltd. Force field analysis. 2009. Available at: http://www.mindtools.com/pages/article/newTED_06.htm. Accessed August 24, 2009. Tidd J, Bessant J, Pavitt K. Innovation management toolbox. 2001. Available at: http://www.wiley.co.uk/wileychi/innovate/website/pages/atoz/atoz.htm. Accessed August 24,	A Force-Field Analysis identifies forces that help and those that hinder reaching the desired outcome. It depicts a situation as a balance between two sets of forces: one that tries to change the status quo and one that tries to maintain it. When opposing forces are equal, no change can occur. For a change to happen, the driving forces must be stronger than the restraining forces. Force-field analysis focuses our attention on ways of reducing the hindering forces and encouraging the positive ones. A Force-Field Analysis identifies forces that help and those that hinder reaching the desired outcome. It depicts a situation as a balance between two sets of forces: one that tries to change the status quo and one that tries to maintain it. Force-field analysis focuses our attention on ways of reducing the hindering forces and encouraging the positive ones. Force-field analysis encourages agreement and reflection in a group through discussion of the underlying causes of a problem.	1. State the problem or desired state and make sure that all team members understand. You can construct the statement in terms of factors working for and against a desired state or in terms of factors working for and against the status quo or problem state. 2. Brainstorm the positive and negative forces. 3. Review and clarify each force or factor. What is behind each factor? What works to balance the situation? 4. Determine how strong the hindering forces are (high, medium, low) in achieving the desired state or from improving the problem state. When the force-field is used for problem analysis, the forces with the biggest impact should be tested as likely causes. If the force-field is used to develop solutions, those factors with the biggest impact may become the focus of plans to reduce resistance to change. 5. Develop an action plan to address the largest hindering forces. 1. WRITE THE DESIRED CHANGE, or	Pros: • Makes it easy to discuss people's objections and examine these concerns • Keeps team members grounded in reality when start planning a change by making them systematically anticipate what kind of resistance they could meet • Encourages team members to raise questions and concerns throughout the process • Encourages communication at all levels of management • Inhibits hierarchical or traditional power structures that are likely to restrict the flow of creative ideas	

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	2009.	Force field analysis clarifies opposing aspects of a desired change: Driving or positive forces that support an action or situation Restraining or negative forces that hinder it When opposing forces are equal, no change can occur. For a change to happen, the driving forces must be stronger than the restraining forces. When all the forces have been considered, plans can be made that will encourage the desired change. Force-field analysis (FFA) is a tool that uses a creative process for encouraging agreement about all facets of a desired change. It is used for clarifying and strengthening the "driving forces" for change. It can also be used to identify obstacles, or "restraining forces" to change. Finally, it can be used for encouraging agreement on the relative priority of factors on each side of the balance sheet. Force field analysis is a helpful tool that can contribute to creating an overview of the situation and possible actions to improve it. Force field analysis is based on the assumption that nay situation is a result of forces for and against the	the problem, at the top of a flipchart or board. Draw a vertical line below it. 2. BRAINSTORM ALL THE DRIVING FORCES that support the change, or cause or enable the problem to occur. Write each one on the left side of the line. Decide how strong that force is, and draw between the words and the line right-pointing arrows whose size or lengths represent that strength. 3. BRAINSTORM ALL THE RESTRAINING FORCES that prevent the action from happening, or prevent or hinder the problem from occurring. Write each one on the right side of the line. Again decide how strong each force is, and draw left-pointing arrows representing that strength. 4. For a desired change, DISCUSS MEANS TO DIMINISH OR ELIMINATE THE RESTRAINING FORCES. For a problem, discuss means to diminish or eliminate the driving forces. Focus especially on the strongest forces. 1. Discuss and come to		

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		current state that are in equilibrium. An increase or decrease in the strength of some of the forces will induce change—a fact that can be used to create positive changes. Force Field Analysis is a useful technique for looking at all the forces for and against a decision. In effect, it is a specialized method of weighing pros and cons. By carrying out the analysis you can plan to strengthen the forces supporting a decision, and reduce the impact of opposition to it. Used: • To help team members to view each case as two sets of offsetting factors • To study existing problems • To anticipate and plan more effectively for implementing change • To define more subjective issues, such as morale, management, effectiveness, and work climate • When the team is planning a change, such as implementation of a solution • When the team is identifying causes of a problem • To identify obstacles to change • For clarifying and	agreement with a group (usually five to seven people) on the current situation and the goal. 2. Write this situation on a flip chart. 3. Brainstorm the “driving” and “restraining” forces. 4. Driving forces are things (actions, skills, equipment, procedures, culture, people, and so forth) that help move toward the goal. 5. Restraining forces are things that can inhibit reaching the goal. 6. Prioritize the driving and restraining forces. 7. Discuss action strategies to eliminate the restraining forces and to capitalize on the driving forces. 1. Clearly define the change desired. This is information that can usually be taken directly form the implementation plan and its improvement objectives. 2. Brainstorm all possible forces in the organization that could be expected to work for or against the change. 3. Assess the strength of each of the forces and place them in a force field diagram. Then length of each		

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		strengthening the “driving forces” for change • For encouraging agreement on the relative priority of factors on each side of the balance sheet	arrow in the diagram expresses the strength of the force it represents. 4. Consider actions that could increase the forces for the change and reduce those against it, especially the stronger forces. * Force field analysis worksheet available in MindTools Expertise: 1 Resources: none		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
Gantt Charts (Also called: milestones chart, project bar chart, activity chart)	Fox J, Black E, Chronokis I, et al. From guidelines to careflows: Modelling and supporting complex clinical processes. In: Teije A, Miksch S, Lucas P, editors. Computer-based medical guidelines and protocols: a primer and current trends. The Netherlands: IOS Press; 2008. p. 44-62. University Research Co. LLC. Quality Assurance Project: Gantt chart. 2008. Available at: http://www.qaproject.org/methods/resclientwindow.html#ganttchart. Accessed July 28, 2009. Tague N. The tools. In: O'Mara P, editor. The quality toolbox. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2005. p. 93-521. Bauer J, Duffy G, Westcott R, editors. The quality improvement handbook, Improvement Tools. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2006. p. 109-48. Mind Tools Ltd. Gantt charts. 2009. Available at:	A Gantt chart is a bar chart that shows the tasks of a project, when each must take place, and how long each will take. As the project progresses, bars are shaded to show which tasks have been completed. People assigned to each task also can be shown. It allows a team to avoid unrealistic timetables and schedule expectations, to help identify and shorten tasks that act as bottlenecks, and to focus attention on the most critical tasks. By adding milestones (interim checkpoints) and completion indicators, the Gantt chart becomes a tool for ongoing monitoring of progress. Illustrates a project schedule, showing the start/finish dates of the component tasks of a project aligned on a timeline and showing the status of planned and active tasks. Some Gantt charts also show dependencies between tasks. A Gantt chart aids planning by showing all activities that must take place and when they are scheduled to occur. This tool helps planners to visualize the work that needs to be completed, the activities that can be overlapped, and deadlines	*Gantt Chart template in ASQ 1. List all the activities that need to be carried out to implement a solution. 2. Determine when each activity must start and list them in chronological order. 3. Draw the framework for the Gantt chart by listing the months of implementation across the top of a sheet of paper. List the activities down the side. 4. For each activity, mark its starting date. Determine the duration for each activity and, using a horizontal bar, mark the duration on the graph. Continue this process for each activity. 5. Review the chart and determine if it is possible to carry out all the activities that are to be conducted simultaneously. 1. **Identify the tasks** that need to be done to complete the project. Also identify key milestones in the project. This may be done by brainstorming a list or by drawing a flowchart, storyboard, or	Pros: • Provides a visual of start dates, durations, and overlap of activities • Forces group members to think clearly about what must be done to accomplish their goal • Easy to construct, understand, and monitor • Can be used for an entire project or for a key phase of a project • Allows a team to avoid unrealistic timetables and schedule expectations • Focuses attention on critical tasks • Allows you to plan the allocation of resources needed to complete the project Cons: • Doesn’t accommodate for uncertainty	

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	http://www.mindtools.com/pages/article/newPPM_03.htm. Accessed August 24, 2009.	for completion. A Gantt chart is a bar chart that shows the tasks of a project, when each must take place, and how long each will take. As the project progresses, bars are shaded to show which tasks have been completed. People assigned to each task also can be shown. The Gantt chart is a type of bar chart used by project managers and others in planning and control to display planned work and targets as well as work that has been completed. A Gantt chart/action plan is a graphic representation of a project's schedule, showing the sequence of critical tasks in relation to time. The chart indicates which tasks can be performed simultaneously. The chart/plan can be used for an entire project or for a key phase of a project. It allows a team to avoid unrealistic timetables and schedule expectations, to help identify and shorten tasks that act as bottlenecks, and to focus attention on the most critical tasks. By adding milestones (interim checkpoints) and completion indicators, the Gantt chart becomes a tool for ongoing monitoring of progress.	arrow diagram for the project. Identify the time required for each task. Finally, identify the sequence. Which tasks must be finished before a following task can begin, and which can happen simultaneously? Which task must be completed before each milestone? 2. **Draw a horizontal time axis** along the top or bottom of a page. Mark it off in an appropriate scale for the length of the tasks (days or weeks). 3. Down the left side of the page, **write each task and milestone** of the project in order. For events that happen at a point in time (such as a presentation), draw a diamond under the time the event must happen. For activities that occur over a period of time (such as developing a plan or holding a series of interviews), draw a bar under the appropriate times on the timeline. Align the left end of the bar with the time the activity begin, and align the right end with the time the activity concludes. Draw just the outline of the bars and diamonds; don't fill them		

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		Gantt Charts are useful tools for analyzing and planning more complex projects. When a project is under way, Gantt Charts help you to monitor whether the project is on schedule. If it is not, it allows you to pinpoint the remedial action necessary to put it back on schedule. Used: • In scheduling projects • To plan a quality improvement project according to activities and time • To understand the overlap and sequence of activities • To monitor progress and re-evaluate deadlines if the project is behind schedule • When scheduling and monitoring tasks within a project • When communicating plans or status of a project • When the steps of the project or process, their sequence, and their duration are known • When it is not necessary to show which tasks depend upon completion of previous tasks • To identify critical tasks or project components • To identify the first task that must be completed • To identify any other tasks that can be started simultaneously with task 1	in. 4. Check that every task of the project is on the chart. 5. As events and activities take place, **fill in the diamonds and bars** to show completion. For tasks in progress, estimate how far along you are and fill in that much of the bar. 6. **Place a vertical marker** to show where you are on the timeline. If the chart is posted on the wall, an easy way to show the current time is with a heavy dark string and two thumbtacks. Expertise: 1 Resources: none		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
		• To identify the next task that must be completed • To identify task durations • To monitor progress			

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Gap Analysis	Mycoted. Creativity and innovation techniques. 2009. Available at: http://www.mycoted.com/Category:Creativity_Techniques. Accessed August 24, 2009.	Gap analysis is a methodical investigation throughout the whole area of a given technology for 'gaps'. Thus highlighting inadequate areas in existing technology that are open to speculation with a view improvement.			Walker J, Bieber E, Richards F, et al. Appendix 3: Gap analysis (for an organ -transplant clinic). In: Walker J, Bieber E, Richards F, editors. Implementing an electronic health record system. London: Springer; 2005. p. 192-6.

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
Goals, Operators, Methods and Selection Rules (GOMS)	Stanton N, Salmon P, Walker G, et al. Task analysis methods. Human factors methods: a practical guide for engineering and design. Great Britain: Ashgate; 2005. p. 45-76.	The Goals, Operators, methods and Selection Rules method is apart of a family of human computer interaction (HCI) based techniques that is used to provide a description of human performance in terms of user goals, operators, methods and selection rules. GOMS attempts to define the user's goals, decompose these goals into sub-goals and demonstrate how the goals are achieved through user interaction. *Goals*. Represent exactly what the user wishes to achieve through the interaction. Goals are decomposed until an appropriate stopping point is reached. *Operators*. The motor or cognitive actions that the user performs during the interaction. The goals are achieved through performing the operators. *Methods*. Describe the user's procedures for accomplishing the goals in terms of operators and sub-goals. Often there are more than one set of methods available to the user. *Selection Rules*. When there is more than one method for achieving a goal available to a user, selection rules highlight which of the available methods should be	1. **Define the user's top-level goals**. Firstly, the analyst should describe the user's top-level goals. They should be described at a very high level. This ensures that any methods are not left out of the analysis. 2. **Goal decomposition**. Once the top-level goal or set of goals has been specified, the next step is to break down the top-level goal into a set of sub-goals. 3. **Determine and describe operators**. Operators are actions executed by the user to achieve a goal or sub-goal. The next phase of the GOMS analysis involves describing the operators required for the achievement of the sub-goals specified during step 2. Each high level operator should be replaced with another goal/method set until the analysis is broken down to the level desired by the analyst. 4. **Determine and describe methods**. Methods describe the procedures or set of procedures used to achieve the goal. In the next phase of the	Pros: • GOMS can be used to provide a hierarchical description of task activity • The methods part of a GOMS analysis fallows the analyst to describe a number of different potential task routes • GOMS analysis can aid designers in choosing between systems, as performance and learning times can be specified • GOMS has been applied extensively in the past and has a wealth of associated validation evidence Cons: • GOMS is a difficult method to apply. Far simpler task analysis methods are available. • GOMS can be time consuming to apply • The GOMS method appears to be restricted to human-computer interaction (HCI). As it was developed specifically for use in HCI, most of the language is HCI oriented. • A high level of training and practice would be required • Context is not taken into consideration • The GOMS methods remain largely invalidated outside of HCI	

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		used. Used: • To provide a description of how a user performs a task, to predict performance times and to predict human learning • For the evaluation of existing designs or systems	GOMS analysis, the analyst should describe each set of methods that the user could use to achieve the task. Often there are a number of different methods available to the user and the analyst is encouraged to include all possible methods. 5. **Describe selection rules**. If there is more than one method of achieving a goal, then the analyst should determine selection rules for the goal. Selection rules predict which of the available methods will be used by the user to achieve the goal. Expertise: 3 Resources: none		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
Groupware Task Analysis (GTA)	Stanton N, Salmon P, Walker G, et al. Team assessment methods. Human factors methods: a practical guide for engineering and design. Great Britain: Ashgate; 2005. p. 365-429.	Groupware Task Analysis is a team task analysis method that is used to analyze team activity in order to inform the design and analysis of similar team systems. GTA comprises a conceptual framework focusing upon the relevant aspects that require consideration when designing systems or processes for teams or organization. The method involves describing the following two task models. • Task model 1 Task model 1 offers a description of the situation at the current time in the system that is being designed. This is developed in order to enhance the design team's understanding of the current work situation. • Task model 2 Task model 2 involves redesigning the current system or situation outlined in task model 1. This should include technological solutions to problems highlighted in task model 1 and also technological answers to requirements specified. Task model 2 should represent a model of the future task world when the new design is implemented. Used: To analyze team activity in order to inform the design	1. **Define system under analysis**. The first step in a GTA is to define the system(s) under analysis. 2. **Data collection phase**. Before task model 1 can be constructed, specific data regarding the existing systems under analysis should be collected. Traditional methods should be used during this process, including observational analysis, interviews and questionnaires. The data collected should be as comprehensive as possible, including information regarding the task (specific task steps, procedures, interfaces used etc.), the personnel (roles, experience, skills etc.) and the environment. 3. **Construct task model 1**. Once sufficient data regarding the system or type of system under analysis has been collected, task model 1 should be constructed. Task model 1 should completely describe the situation as it currently stands, including the agents, work and situation categories outlined above.	Pros: • GTA output provides a detailed description of the system requirements and highlights specific issues that need to be addressed in the new design • Task model 2 can potentially highlight the technologies required and their availability • GTA provides the design team with a detailed understanding of the current situation and problems • GTA seems to be suited to the analysis of existing command and control systems Cons: • GTA appears to be extremely resource intensive and time consuming in its application • Limited evidence of use in the literature • The method provides limited guidance for its application • A large team of analysts would be required in order to conduct a GTA analysis	

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
		and analysis team systems To model a future task world when a new design is implemented To identify technological solutions to problems highlighted	4. **Construct task model 2**. The next stage of the GTA is to construct task model 2. Task model 2 involves redesigning the current system or situation outlined in task model 1. The procedure used for constructing task model 2 is determined by the design teams, but may include focus groups, scenarios and brainstorming sessions. 5. **Redesign the system**. Once task model 2 has been constructed, the system redesign should begin. Obviously, this procedure is dependent upon the system under analysis and the design team involved. Expertise: 2 Resources: none		

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Heuristic Evaluation (Also called: Heuristic Analysis)	Stanton N, Salmon P, Walker G, et al. Interface analysis methods. Human factors methods: a practical guide for engineering and design. Great Britain: Ashgate; 2005. p. 431-81.	Heuristic analyses methods offer a quick and simple approach to interface evaluation. Heuristic analysis involves analysts providing subjective opinions based upon their interaction with a particular design, device or product. Heuristic analysis is a flexible approach that can be used to assess a number of features associated with a particular product or interface, including usability, error potential, mental workload and overall design quality. To conduct a heuristic analysis, an analyst or team of analysts perform a series of interactions with the product or interface under analysis, recording their observations as they proceed. Heuristic type analyses are typically conducted throughout the design process in order to evaluate design concepts and propose remedial measures for any problems encountered. The popularity of heuristic analysis lies in its simplicity and the fact that it can be conducted easily and with only minimal resource usage, at any stage throughout the design process. Used: • To assess features associated with a particular	1. **Define tasks under analysis**. The first step in a heuristic analysis is to define a representative set of tasks or scenarios for the system or device under analysis. It is recommended that heuristic analyses are based upon the analyst performing an exhaustive set of tasks with the device in question. The tasks defined should then be placed in a task list. It is normally useful to conduct a hierarchal task analysis (HTA) for this purpose, based on the operation of the device in question. The HTA then acts as a task list for the heuristic analysis. 2. **Define heuristic list**. In some cases it may be fruitful to determine which aspects are to be evaluated before the analysis begins. Typically, usability (ease of use, effectiveness, efficiency and comfort) and error potential are evaluated. 3. **Familiarization phase**. To ensure that the analysis is as comprehensive as possible, it is recommended that the	Pros: • Heuristic analysis offers a quick, simple and low-cost approach to usability assessment • Due to its simplicity, only minimal training is required • Heuristic analysis can be applied to any form of product, including paper-based diagrams, mock-ups, prototype designs and functional devices • The output derived is immediately useful, highlighting problems associated with the device in question • Very low resource usage • Can be used repeatedly throughout the design life cycle Cons: • Poor reliability, validity and comprehensiveness • Requires subject-matter experts in order for the analysis to be worthwhile • Subjective • Totally unstructured • Consistency of such a technique is questionable	

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
		product or interface, such as usability, error potential, mental workload and overall design quality	analysts involved spend some time to familiarize themselves with the device in question. This might involve consultation with the associated documentation (e.g. instruction manual), watching a demonstration of the device being operated, or being taken through a walkthrough of device operation. 4. **Perform task(s)**. Once familiar with the device under analysis, the analyst(s) should then perform each task from the task list developed during steps 1 and 2 and offer opinions regarding the design and the heuristic categories required. During this stage, any good points or bad points associated with the participants' interactions with the device should be recorded. If the analysis concerns a design concept, then a task walkthrough is sufficient. Each opinion offered should be recorded. 5. **Propose remedies**. Once the analyst has completed all of the tasks form the task list, remedial measures for		

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			any of the problems recorded should be proposed and recorded. Expertise: 2 Resources: none		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
Hierarchical Task Analysis (HTA)	Stanton N, Salmon P, Walker G, et al. Task analysis methods. Human factors methods: a practical guide for engineering and design. Great Britain: Ashgate; 2005. p. 45-76.	Hierarchical task analysis (HTA) is the most popular task analysis method and has become perhaps the most widely used of all human factors methods available. Originally developed in response to the need for greater understanding of cognitive tasks, HTA involves describing the activity under analysis in terms of goals, sub-goals, operations and plans. The end result is an exhaustive description of task activity. Used: • To develop a comprehensive list of subtasks or goals for a certain task or process	1. **Define task under analysis**. The purpose of the task analysis effort should also be defined. 2. **Data collection process**. The data collected during this process is used to inform the development of the HTA. Data regarding the task steps involved, the technology used, interaction between man and machine and team members, decisionmaking and task constraints should be collected. There are a number of ways to collect this data, including observations, interviews with subject matter experts (SMEs), questionnaires, and walkthroughs. The methods used are dependent upon the analysis effort and the various constraints imposed, such as time and access constraints. 3. **Determine the overall goal of the task**. The overall goal of the task under analysis should first be specified at the top of the hierarchy. 4. **Determine task sub-goals**. Break down the overall goal down into	Pros: • HTA requires minimal training and is easy to implement • The output of HTA is extremely useful and forms the input for numerous human factor analyses • HTA is an extremely flexible method that can be applied in any domain for a variety of purposes • Quick to use in most instances • The output provides a comprehensive description of the task under analysis • HTA has been used extensively in a wide range of contexts • Conducting an HTA gives the user an great insight into the task under analysis • HTA is an excellent method to use when requiring a task description for further analysis. If performed correctly, the HTA should depict everything that needs to be done in order to complete the task in question. • Tasks can be analyzed to any required level of detail, depending on the purpose Cons: • Provides mainly descriptive information rather than analytical information • HTA contains little that can be used directly to provide design solutions	Chung P, Zhang J, Johnson T, et al. An extended hierarchical task analysis for error prediction in medical devices. AMIA 2003 Symposium Proceedings; 2003: AMIA; 2003. p. 165.

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			meaningful sub-goals, which together form the tasks required to achieve the overall goal. 5. **Sub-goal decomposition**. Break down the sub-goals identified into further sub-goals and operations, according to the task step in question. This process should go on until an appropriate operation is reached. The bottom level of any branch in a HTA should always be an operation. Whilst everything above an operation specifies goals, operations actually say what needs to be done. Therefore operations are actions to be made by an agent in order to achieve the associated goal. 6. **Plans analysis**. Once all of the sub-goals and operations have been fully described, the plans need to be added. Plans dictate how the goals are achieved. A simple plan would say Do 1, then 2, and then 3. Once the plan is completed, the agent returns to the super-ordinate level. Plans do not have to be linear and exist in many forms,	• HTA does not cater for the cognitive components of the task under analysis • The method may become laborious and time consuming to conduct for large, complex tasks • The initial data collection phase is time consuming and requires the analyst to be competent in a variety of HF methods, such as interviews, observations, and questionnaires • The reliability of the method may be questionable in some instances. For example, for the same task, different analysts may produce very different task descriptions • Conducting a HTA is more of an art than a science, and much practice is required before an analyst becomes proficient in the application of the method • An adequate software version of the method has yet to emerge	

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			such as Do 1, or 2 and 3. Expertise: 2 Resources: none		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
Histogram (Also called: frequency distribution)	American Society for Quality. Data collection and analysis tools: Histogram. 2009. Available at: http://www.asq.org/learn-about-quality/data-collection-analysis-tools/overview/histogram.html. Accessed July 28, 2009. Hummel P, Gamble T. Reporting and analysis. In: Norris T, Fuller S, Goldberg H, et al., editors. Informatics in primary care. New York: Springer; 2002. p. 187-213. University Research Co. LLC. Quality Assurance Project: Histogram. 2008. Available at: http://www.qaproject.org/methods/reshistorgram.html. Accessed July 28, 2009. Tague N. The tools. In: O'Mara P, editor. The quality toolbox. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2005. p. 93-521. Bauer J, Duffy G, Westcott R, editors. The quality improvement handbook, Improvement Tools. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2006. p. 109-48.	A histogram is a graphic representation (bar chart) used to plot the frequency with which different values of a given variable occur. The frequency of occurrence of any given value is represented by the height of the bar. Histograms are used to examine existing patterns, identify the range of variables, and suggest a central tendency in variables. A frequency distribution shows how often each different value in a set of data occurs. A histogram is the most commonly used graph to show frequency distributions. Most commonly used frequency distribution tool. Tells us how a single variable is distributed. It graphically displays the distribution of a data set by presenting the measurement scale of values along its x-axis and a frequency scale (as counts or percents) along its y-axis. The histogram displays a single variable in a bar form to indicate how often some event is likely to occur by showing the pattern of variation (distribution) of data. A pattern of variation has three aspects: the center (average), the shape of the curve, and the width of the curve. Histograms are constructed with variables—	Can easily be constructed in excel or using ASQ's histogram template *Histogram template in ASQ Note: A histogram can easily be constructed using Microsoft Excel or most other spreadsheet software. If you prefer to create one by hand, use the following procedure. 1. From the raw numbers (the data), **find the highest and lowest values**. This is the range. 2. **Determine the number of bars** to be used in the histogram. If too many bars are used, the pattern may become lost in the detail; if too few are used, the pattern may be lost within the bars. 3. **Determine the width** of each bar by dividing the range by the number of bars. Then, starting with the lowest value, determine the grouping of values to be contained or represented by each bar. 4. **Create a compilation table** and fill in the boundaries for each grouping. 5. **Fill in the compilation table** by counting the number of data points for each bar	Pros: • Can help determine whether data collected is normally distributed • If a process is stable, the histogram can predict future performance • Can easily be constructed in spreadsheet software • Allows a person to quickly visualize the center (average), variation (spread), and shape of the distribution of measurements • Shows patterns in measurements • Provides clues to reducing variation and causes of problems • Shows the production consistency of a quality characteristic • Graphically shows the relationship between the capability of the process and the engineering specifications • Visually assesses whether a set of measurements is normally distributed • Visual • Simple and powerful • Quickly summarizes large amounts of data • May be used to show relationship of key characteristic variation to engineering specifications Cons: • Need at least 50 data points or observations for a decent quality histogram • Any interpretation of a histogram shape is only a theory that must be verified	

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
Interview	George M, Rowlands D, Price M, et al. Voice of the customer. The lean six sigma pocket toolbook. New York: McGraw–Hill; 2005. p. 55-68. Tague N. The tools. In: O'Mara P, editor. The quality toolbox. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2005. p. 93-521.	Interviews collect data (generally qualitative) from a targeted group of people about their opinions, behavior, or knowledge. Interviews can be conducted face-to-face, over the phone, or via Webcam. Used: • To learn about a specific customer's point of view on service issues, product/service attributes, and performance indicators/measures • At the beginning of a project: to learn what is important to customers • In the middle of a project: to clarify points or to better understand why a particular issue is important to customers, to get ideas and suggestions, or to test ideas with customers • At the end of a project: to clarify findings, to validate improvement • When the group to be surveyed is small • When the questions to be asked are sensitive • When possible answers to the questions are not known, such as when you first begin studying an issue • When the people to be surveyed are high-ranking, important, or otherwise deserving of special attention	1. **Be clear about the purpose** of the interviews. What role will the interviews play in the project? How will you use the information afterwards? 2. Prepare a list of questions. 3. **Decide on interview method** (face-to-face, phone). 4. Decide how many interviews and interviewees will be present. 5. **Do practice interviews** internally to refine the script, questions and interview process. 6. **Contact customers and arrange interviews**. Send out a confirmation letter or email stating the purpose of the interview and providing a list of general topics to be covered. 7. **Decide how you will collect data** from the interviews. If you plan to record them (audiotape, computer audio programs) make sure you tell customers and get their permission to do so. 8. Conduct interviews. 9. Transcribe notes and continue with data analysis.		

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		• When close to 100% response rate is needed	Expertise: 1 Resources: audio recorder		

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Kano Analysis	George M, Rowlands D, Price M, et al. Voice of the customer. The lean six sigma pocket toolbook. New York: McGraw–Hill; 2005. p. 55-68.	The Kano Analysis is a qualitative graph that relates customer satisfaction and customer needs. The purpose of the Kano Analysis is to better understand what value your customers place on the features of your product or service, which can reduce the risk of providing products or services that over-emphasize features of little importance or that miss critical-to-quality features/attributes. Used: • As a good "first cut" technique to evaluate relative importance of customer requirements • To determine if there are requirements that were not explicitly stated by customers • To determine if there are requirements that were included in previous offerings and are still valued by the customer • After interviews or focus groups to confirm that some needs spoken by the customer are truly critical requirements that will affect customer satisfaction or purchasing decisions • In Define or Measure (of the DMAIC process) to understand scope and importance of project goals • In Improve (of the DMAIC	1. **Collect voice of customer (VOC) data** through as many different means as you can. 2. Identify known or presumed customer needs/requirements. 3. For each potential need, **ask the customer** to assess: a. How would they feel if the need WAS addressed? b. How would they feel if the need WAS NOT addressed? Customer can respond: I'd like it, It is normally that way, I don't care, or I wouldn't like it 4. Based on customer responses, **classify each need** as a dissatisfier, satisfier, or delighter. 5. **Incorporate this information** into product or service development efforts. Expertise: 2 Resources: none	Pros: • Allows you to identify segments by the type or level of quality that customers expect	

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		process) to help redesign a product, service, or process			

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
Kepner-Tregoe Matrix (Also called: is-is not matrix)	Lighter D. Process orientation in health care quality. In: Moore C, editor. Quality management in health care: principles and methods. 2 ed. Sudbury, MA: Jones and Bartlett Publishers; 2004. p. 43-101. Tague N. The tools. In: O'Mara P, editor. The quality toolbox. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2005. p. 93-521. Andersen B. Tools for analyzing the performance shortcoming. In: O'Mara P, editor. Business process improvement toolkit. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2007. p. 123-55. Mycoted. Creativity and innovation techniques. 2009. Available at: http://www.mycoted.com/Category:Creativity_Techniques. Accessed August 24, 2009.	Developed primarily to isolate and identify causes of quality problems, the Kepner-Tregoe matrix helps managers recognize factors that underlie defects in a process. Most often used in a brainstorming environment, the KTM relates possible causes to specific categories, e.g., who, what, when, where, how, and why. The is-is not matrix guides the search for causes of a problem. By isolating who, what, when, where, and how about an event, it narrows investigation to factors that have an impact and eliminates factors that do not have an impact. By comparing what the problem *is* with what the problem *is not*, we can see what is distinctive about this problem, which leads to possible causes. The is-is not analysis is a tool that helps you see distinctions and clarify what the problem is *not* about. Using this tool can help you understand what is most likely to cause the performance shortcoming as well as identify which issues are definitely not related to it. Even at a later stage in the improvement cycle, when many ideas for improvement	1. **Describe the event** so that everyone clearly understands the problem. Describe it as a deviation from the way things should be. Write the problem statement in the upper left corner of the is-is not matrix. 2. **Produce an empty matrix** of six rows by four columns and fill the headings of the 4 columns with "Performance shortcoming," "Is," "Is not," and "Distinction." Fill the headings of the rows below the top one with "What occurs, what objects are affected?," "Where does the problem occur?," "When does the problem occur?," "Extent of shortcomings?," and "Who is involved?" 3. In the upper-left corner of the matrix, **state the problem or event** being analyzed. 4. Using the "Is" column of the matrix, **describe what did or does occur**. a. Determine what objects are affected and what exactly occurs. Be as specific as possible. b. Determine where the event occurs. This can be geographical, a physical location, on an	Pros: • Provides an excellent means for improvement teams to find problems in processes and develop ways to resolve them • Sufficiently exhaustive to ensure that process problems can be defined accurately • Can be used any time in the process improvement effort Cons: • Time consuming	

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		actions are on the table, the analysis can be used to distinguish between what is and what is not related to the shortcoming. Used: • In brainstorming • To isolate and identify causes of quality problems • To clarify what the problem is not about	object, or a combination. c. Determine when the event occurs. When did it happen first? When since? What patterns of occurrence have you noticed? Date, time, day, and season can all be important to the solution. Also, when the event occurs in relation to other events (before, after, during) can be significant. 5. **Determine how many or how much**—the extent of the problem. How many objects or occurrences had problems? How many problems? How serious are they? 6. **Determine who** is involved in the event. To whom, by whom, near whom does it occur? However, this analysis should never be used to assign blame—only to determine cause. 7. Use the "Is not" column of the matrix to **identify circumstances** that could occur but do not. Again use the what, where, when, how many or much (extent), and who questions. 8. Study the "Is" and "Is not" columns to **identify what is different or unusual** about the situations where the		

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			problem is compared to where it is not. What stands out as being odd? What changes have occurred? Write your observations in the column headed "Distinctions." 9. **For each distinction ask**, "Does this distinction relate to a change we know about?" and "How could this distinction (or change) have caused our problem?" Write down all possible causes, including both what caused the problem and how it did so. 10. **Test all possible causes by asking**, "If this is the cause, does it explain every item in the "Is" and "Is not" columns?" The most likely cause must explain every aspect of the problem. 11. If possible, **plan an experiment to verify the cause(s)** you have identified. Depending on the cause, either try to duplicate the problem by "turning on" the cause, or try to stop the problem by reversing a change that caused it. 1. Characterize the problem items that are		

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			understandable to the quality improvement team and that can create agreement on the nature of the predicament. 2. Create the matrix using a regular table format (categories in the left-most vertical row and the top horizontal row). 3. Have the quality improvement team formulate entries for each cell in the matrix, answering the questions of who, what, when, where, and how for the problem. A fundamental tenet of quality improvement needs to be re-emphasized here: the process is the problem, not the person trying to implement or work within the process. Thus, the "who" questions are simply to help focus on process deficiencies, not to assign blame. 1. Describe the event so that everyone clearly understands the problem. Describe it as a deviation from the way tings should be. Write the problem statement in the upper left corner of the is-is not matrix. 2. Using the "Is" column		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
			of the matrix, describe what did or does occur. 3. Determine what objects are affected and what exactly occurs. Be as specific as possible. 4. Determine where the event occurs. This can be geographical, a physical location, on an object, or a combination. 5. Determine when the event occurs. When did it happen first? When since? What patterns of occurrence have you notice? Date, time, day, and season can all be important to the solution. Also, when the event occurs in relation to other events (before, after, during) can be significant. 6. Determine how many or how much—the extent of the problem. How many objects or occurrences had problems? How many problems? How serious are they? 7. Determine who is involved in the event. To whom, by whom, near whom does it occur? However, this analysis should never be used to assign blame—only to determine cause. 8. Use the “Is not” column of the matrix to identify circumstances		

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			that could occur but do not. Again use the what, where, when, how many or much (extent), and who questions. 9. Study the "Is" and "Is not" columns to identify what is different or unusual about the situations where the problem is compared to where it is not. What stands out as being odd? What changes have occurred? Write your observations in the column headed "Distinctions." 10. For each distinction ask, "Does this distinction relate to a change we know about?" and "How could this distinction (or change) have caused our problem?" Write down all possible causes, including both what caused the problem and how it did so. 11. Test all possible causes by asking, "If this is the cause, does it explain every item in the "Is" and "Is not" columns?" The most likely cause must explain every aspect of the problem. 12. If possible, plan an experiment to verify the causes) you have		

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			identified. Depending on the cause, either try to duplicate the problem by “turning on” the cause, or try to stop the problem by reversing a change that caused it. 1. Produce an empty matrix of six rows by four columns and fill the headings of the 4 columns with “Performance shortcoming,” “Is,” “Is not,” and “Distinction.” Fill the headings of the rows below the top one with “What occurs, what objects are affected?,” “Where does the problem occur?,” “When does the problem occur?,” “Extent of shortcomings?,” and “Who is involved?” 2. In the upper-left corner of the matrix, state the performance shortcoming being analyzed. 3. Fill in the second column with “is” information: what, where, when, who, and so on. 4. In the same manner, fill in the third column with “is not” information. 5. Compare the two columns for anything odd or that stands out and place these in the		

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			fourth column. 6. For each element in the fourth column, analyze how it could be a cause of the performance shortcoming. 7. For the possible causes identified this way, test them by checking if they explain all items in the "is" and "is not" columns. Those that do are likely the real cause(s). Expertise: 1 Resources: none		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
Lean (Also called: Toyota Production System (TPS))	Koelling C, Eitel D, Mahapatra S, et al. Value stream mapping the emergency department. 17th Annual Society for Health Systems Management Engineering Forum; 2005; Dallas, TX; 2005. Lucansky P, Burke R. Lean six sigma in the office. The tools and techniques to streamlining your office processes. 17th Annual Society for Health Systems Management Engineering Forum; 2005; Dallas, TX; 2005. Johnson C, Allen R, Wedgewood I. Attacking waste and variation hospital-wide: A comprehensive lean-sigma deployment. 2007 Society for Health Systems Conference; 2007; New Orleans, LA; 2007. Morrissette M, Reed K. Lean health care hands-on simulation workshop to improve performance & quality. 2007 Society for Health Systems Conference; 2007; New Orleans, LA; 2007. Quetsch J. Patient safety with six sigma, lean, or	A systematic methodology to reduce complexity and streamline a process by identifying and eliminating sources of waste in the process; waste that typically causes a lack of flow. Waste is considered to be any activity that does not add value to the desired outcome or product. There are seven types of waste: overproduction, unnecessary transportation, inventory, motion, defects, over-processing, and waiting. Lean thinking includes processes that are flexible, reduce waste, optimize the process, improve process control and finally improves utilization of people resources. Lean is focused on reducing waste through increasing speed, reducing process inventory and decreasing process cycle times. A systematic methodology to reduce complexity and streamline a process by identifying and eliminating sources of waste in the process; waste that typically causes a lack of flow. Lean manufacturing refers to a system of methods that emphasize identifying and eliminating all non-value-	No process *Link to all lean tools Expertise: varies Resources: varies	Pros: • Anyone in organization can participate • Does not require a format to make change happen • Investment in Lean is low to moderate • Many resources and books available • Adapt to do more with same resources • Eliminates waste within a process	Smith M, Cunningham S. Case study: using lean principles, how Charleston area medical center ED was able to reduce wait time by 95%. 2007 Society for Health Systems Conference; 2007; New Orleans, LA; 2007.

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	theory of constraints. 2007 Society for Health Systems Conference; 2007; New Orleans, LA; 2007. Woodward H, Suskovich D, Workman-Germann J, et al. Adaptation of lean methodologies for health care applications. 2007 Society for Health Systems Conference; 2007; New Orleans, LA; 2007. Woodcock E. The lean-thinking revolution. Mastering patient flow: using lean thinking to improve your practice operations. . 3rd ed. Englewood: Medical Group Management Association; 2009. p. 11-40. Medical Group Management Association. Think lean: Redesign workflow to adopt EHR. MGMA Connexion 2007;7(1):17-8. Tague N. Mega-tools: Quality management systems. In: O'Mara P, editor. The quality toolbox. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2005. p. 13-34.	adding activities—waste—from a manufacturing or manufacturing support organization. Processes become faster and less expensive. Lean manufacturing is characterized by fast cycle times, just-in-time methods, pull systems, little or no inventory, continuous flow or small lot sizes, production leveling, and reliable quality. Lean organizations are efficient, flexible, and highly responsive to customer needs. Used: • To eliminate waste (non-value adding activities) in a process			

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Lean Six Sigma	Avni T. Value stream mapping and simulation modeling: An integrated approach to workflow analysis in health care. 2007. Available at: http://www.nahq.org/journal/online/septoct2007.pdf. Accessed June 24, 2009. Lucansky P, Burke R. Lean six sigma in the office. The tools and techniques to streamlining your office processes. 17th Annual Society for Health Systems Management Engineering Forum; 2005; Dallas, TX; 2005. Johnson C, Allen R, Wedgewood I. Attacking waste and variation hospital-wide: A comprehensive lean-sigma deployment. 2007 Society for Health Systems Conference; 2007; New Orleans, LA; 2007.	Lean Sigma combines the power of two proven methodologies: Lean and Six Sigma. Lean aims to streamline processes by eliminating waste or non-value-added activities, while Six Sigma focuses on reducing process variation to minimize the number of defects (the Six Sigma level = 3.4 defects per million opportunities). Lean Sigma is all about linkage of tools, and not using tools individually. In fact, none of the tools are new. The strength of the approach is in the sequence of tools. Lean Sigma approaches sustainable continuous improvement with the goal of improving patient care, safety, and satisfaction while simultaneously reducing costs and increasing revenues.	No process Expertise: varies Resources: varies	Pros: Little or no capital investment	Exline K, Martin V. Using lean six sigma to reduce surgery cancellation rate. 2007 Society for Health Systems Conference; 2007; New Orleans, LA; 2007. Bisgaard S. Solutions to the Healthcare Quality Crisis: Cases and Examples of Lean Six Sigma in Healthcare. Milwaukee, WI: ASQ Quality Press; 2009.

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List Reduction	Tague N. The tools. In: O'Mara P, editor. The quality toolbox. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2005. p. 93-521.	List reduction is a set of techniques that are used to reduce a brainstormed list of options (such as problems, solutions, measures) to a manageable number. Used: • After brainstorming or some other expansion tool has been used to generate a long list of options • When a list must be narrowed down • When a list of options may have duplicate or irrelevant ideas • When the group members together should think through the reasons for eliminating choices to reach consensus	1. Post the entire list of brainstormed ideas so that everyone can see all items. 2. **For each item, ask the question**, “Should this item continue to be considered?” Get a vote of yeses and nos. A simple majority of yes responses keeps the item on the list. If an item does not get a majority of yes votes, mark it with brackets. 3. After all items have been evaluated by the wide filter, **ask the team members**, “Does anyone want to put any of the bracketed items back on the list?” Any items that are mentioned by even one team member are left on the list. Remaining bracketed items are crossed off. 4. **Label the first idea** on the list number 1. Look at the second idea. Ask, “Does anyone think this is a different idea from number 1?” If one person thinks the second idea is different, label the second idea number 2. If all agree that the two items really are the same, eliminate one or develop new wording to combine the two ideas.	Pros: • Simple and straightforward method to reduce a list of options	

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			5. Similarly, **compare item number 1 to all other items** on the list, one at a time. 6. **Take item number 2 and compare it to each item below it** on the list. Continue to work down the list until all the ideas have been compared pairwise. Ever idea should be either numbered or eliminated. Expertise: 1 Resources: flip chart		

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Log (Also called: work log, work diary)		A log is a generic data collection form used for recording what has been done, when it was done, who did it, and other information pertinent to the situation. Since a log is so generic, it is generally user created to apply to the user's particular situation. A log is usually in some type of table format, where there are columns for recording information such as time, location, personnel, and then usually a main column recording what happened or what was done. A log can be used to record pieces of information ranging from one word to a paragraph or even more. Used: • To record just about any type of information from a process or set of processes into a organized format	Expertise: 1 Resources: none	Pros • Organizes information from a process or set of processes	Hundt AS, Carayon P, Smith PD, et al. A macroergonomic case study assessing electronic medical record implementation in a small clinic. Human Factors and Ergonomics Society Annual Meeting Proceedings 2002;46:1385-8.

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
Matrix Diagram	Tague N. The tools. In: O'Mara P, editor. The quality toolbox. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2005. p. 93-521. Andersen B. Tools for analyzing the performance shortcoming. In: O'Mara P, editor. Business process improvement toolkit. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2007. p. 123-55.	The matrix diagram shows the relationship between two, three, or four groups of information. It can also give information about the relationship, such as its strength, the roles played by various individuals, or measurements. Six different shaped matrices are possible: L-, T-, Y-, X-, C-, and roof-shaped, depending how many groups must be compared. This is a generic tool that can be adapted for a wide variety of purposes. The matrix diagram has the unique ability to graphically portray the strength of cause-and-effect relationships. Like many other cause-and-effect based tools, the matrix diagram can also be used in several stages of improvement work, such as prioritizing improvement areas, identifying problems and causes, and planning. Used: • When trying to understand how groups of items relate to one another • When communicating to others how groups of items relate to one another • When distributing responsibilities for tasks among a group of people • When linking customer requirements to elements of a process • When sorting out which problems are affecting which products or which	1. Decide what groups of items must be compared. 2. Choose the appropriate format for the matrix. 3. **Draw the lines** forming the grid of the matrix. 4. **List the items** in each group as row labels and column headings. 5. **Decide what information** you want to show with the symbols on the matrix. 6. **Compare groups**, item by item. For each comparison, mark the appropriate symbol in the box at the intersection of the paired items' column and row. 7. **Analyze the matrix** for patterns. You may wish to repeat the procedure with a different format or a different set of symbols to learn more about the relationships. 1. Select the variables to be analyzed for potential relationships. 2. Select the matrix format according to the number of variables and the number of expected relations. 3. Insert the variables into the diagram. 4. Indicate relations by using symbols. Do not be tempted to use	Pros: • Show relationships very well • Many different formats of matrix diagrams can be used depending on the situation • Can be used in several stages of improvement work	

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
Metrics Evaluation	Geiger G, Derman Y. Methodology for evaluating physician order entry (POE) implementations. J Eval Clin Pract 2003;9(4):401-8.	Metrics evaluation develops a set of metrics that can clearly identify and compare pre-implementation system performance, with regard to the objectives, against post-implementation performance. It is important to assess the actual time costs of various components of clinicians' workload before and after implementation so that perceptions of change can be compared with reality. This information can be used strategically—to market the benefits of the system to clinicians, but it should also be used to validate clinicians' perceptions of the system after implementation. If the system has a negative impact on the workflow, the implementation plan should be revised to address the problems identified. Used: • To evaluate the areas in which the organization expects strategic improvement • To determine the overall impact to patient care	1. **Formulating metrics to evaluate the attainment of stakeholders' objectives**—establish metrics that will measure when an objective has been satisfied. The definition of the metrics will be derived from the stated objectives. Metrics can be objective (changes in time, cost, outcomes) and subjective (changes in perception, quality, satisfaction). 2. **Assessing the pre-implementation system state**—data needs to be collected to assess the current state of the clinical system with respect to the objectives (as represented by the metrics) of all stakeholders. While the nature of the data requirements should dictate the method of data collection, it is important to stress that qualitative and quantitative methods complement each other and both should be used to provide a representation of the clinical system. At this time, the matter of course changes in health care (clinician		

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			rotations, policy changes, technology changes, bed closures/openings, etc.) should be identified, and their potential impact on the data element values should be assessed as well as possible. Finally, methods for collecting the post-implementation data for these elements should be identified. 3. **Specifying targets for objectives and anticipating compromises**—stakeholder groups should formulate a compromise vector of target values for all the objectives by which the implementation will be considered a success. More than one vector should be constructed to represent acceptable trade-offs between the over-achievement of some stakeholders' objectives in return for the under-achievement of others. 4. **Establishing post-implementation assessment milestones**—stakeholders should negotiate multiple milestones for evaluating the status of the clinical system post-implementation. The		

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			length of time between implementation and evaluation affects the attitudes and metric values. 5. **Assessing the post-implementation system state**—post-implementation data to support the metrics should be collected and evaluated at the pre-specified milestones. Stakeholders should meet to determine whether action must be taken to eliminate discrepancies between current and target-state metric values and to coordinate these actions. Before taking action, it is important to ascertain whether other organizational changes, which have transformed the initial assumptions by which objectives were specified, may be the cause of the discrepancies. Expertise: 2 Resources: none		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
Multi-vari Chart (Also called: multivariate chart)	Tague N. The tools. In: O'Mara P, editor. The quality toolbox. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2005. p. 93-521.	The multi-vari chart shows which of several sources of variation are the greatest contributors to total variation and may reveal other patterns in the variation. Used: • When studying sources of variation in a process • When you wish to identify the most important sources of variation • When the output characteristic is a variable measurement	1. **Identify the possible sources of variation** you wish to study. Create a sampling tree showing the combinations of settings for sources A, B, and C. 2. **Create a graph** with the y-axis representing the output characteristic. Divide the x-axis into a section for each setting of the A source, the top level of the sampling tree. Divide each of those sections into subsections for each setting of the B source. Points plotted in a vertical line show the measurements at different settings of source C. 3. **Calculate the mean** of the values in the first line of points. Mark the value along the line with a symbol different from the points. Repeat for each B group in the first section of the chart. 4. **Connect the means** of the B groups within the first section of the chart. 5. **Calculate the mean** of all values in the first section. (This will be the average of the means calculated in step 3.) **Mark the value** with a third symbol at the centerline of the section.		

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			6. **Repeat steps 3, 4, and 5** for each section of the chart representing each setting of source A. 7. **Connect the symbols** for the overall means for each section. 8. **Analyze the chart** to identify the greatest source of variation and any patterns of variation. Expertise: 2 Resources: none		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
Multivoting	McCray M. How to get paid for the services you provide. 2007 Society for Health Systems Conference; 2007; New Orleans, LA; 2007. Lighter D. Group processes in health care quality improvement. In: Moore C, editor. Quality management in health care: principles and methods. 2 ed. Sudbury, MA: Jones and Bartlett Publishers; 2004. p. 13-41. George M, Rowlands D, Price M, et al. Working with ideas. The lean six sigma pocket toolbook. New York: McGraw–Hill; 2005. p. 27-32. Tague N. The tools. In: O'Mara P, editor. The quality toolbox. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2005. p. 93-521. Bauer J, Duffy G, Westcott R, editors. The quality improvement handbook, Improvement Tools. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2006. p. 109-48.	Multi-Voting is a prioritization tool. Narrows a list of ideas to a final selection. It allows an idea that has a simple majority to gain popularity, even if it is not one of the top choices. A quick technique for identifying priorities or at least narrowing down the options from a list of ideas. Multivoting narrows a large list of possibilities to a smaller list of the top priorities or to a final selection. Multivoting is preferable to straight voting because it allows an item that is favored by all, but not the top choice of any, to rise to the top. Multivoting is a quick and easy way for a group to identify the items of the highest priority in a list. Used: • To narrow a list of ideas or choices • After a session that produces a multitude of unorganized ideas • After brainstorming or some other expansion tool has been used to generate a long list of possibilities • When the list must be narrowed down	Each Team Member gets 1/3 as many votes as there are ideas. For example, if there are 6 ideas, each team member gets 2 votes. Team Members place their dots on what they think is the highest priority. A Team Member can choose to place dots on separate categories or all in one. After everyone is done voting, ideas are tallied and ranked by priority. The top priority items will be discussed individually if no clear top-priority emerges from the voting process. 1. Using a list of ideas from one of the idea-creation techniques, number each item in sequence. 2. Allow each member of the team to vote for one third of the items. 3. Tally the votes, either by secret ballot or a show of hands, and reduce the list by eliminating the items receiving the fewest votes. 4. Repeat process until a single item emerges as the clear winner. 1. Number every idea or option being considered.	Pros: • Simple and straightforward • Quick and easy to use Cons: • Does not guarantee consensus	

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		• When the decision must be made by group judgment • To prioritize a large list without creating a win-lose situation in the group that generated the list • To separate the "vital few" items from the "useful many" on a large list	2. Write each idea on a flip chart or whiteboard visible to all participants. 3. Decide how many votes each person will have. 4. Cast votes. 5. Count votes. 6. Decide on course of action. 1. Display the list of options. Combine duplicate items. Affinity diagrams can be useful to organize large numbers of ideas and eliminate duplication and overlap. List reduction may also be useful. 2. Number (or letter) all items. 3. Decide how many items must be on the final reduced list. Decide also how many choices each member will vote for. Usually, five choices are allowed. The longer the original list, the more votes will be allowed, up to 10. 4. Working individually, each member selects five items (or whatever the number of choices allowed) he or she thinks most important. Then each member ranks the choices in order of priority, with the first choice ranking		

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			highest. For example, if each member has five votes, the top choice would be ranked five, the next choice four, and so on. Each choice is written on a separate paper, with the ranking underlined in the lower right corner. 5. Tally votes. Collect the papers, shuffle them, then record on a flipchart or whiteboard. The easiest way to record votes is for the scribe to write all the individual rankings next to each choice. For each item, the rankings are totaled next to the individual rankings. 6. If a decision is clear, stop here. Otherwise, continue with a brief discussion of the vote. The purpose of the discussion is to look at dramatic voting differences, such as an item that received both 5 and 1 ratings, and avoid errors from incorrect information or understandings about the item. The discussion should not become pressure on anyone to change their vote. 7. Repeat the voting process of steps 4 and 5. If greater decisionmaking		

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			accuracy is required, this voting may be done by weighting the relative importance of each choice on a scale of 1 to 10, with 10 being most important. 1. **Give each team member a number of votes** equal to approximately half the number of items on the list (for example, 10 votes for a 20-item list). 2. **Have team members vote** individually for the items they believe have high priority. Voters can "spend" their votes as they wish, even giving all to one item. 3. **Compile the votes** given to each item and record the quantity of votes beside each item. 4. **Select the four to six items** receiving the highest number of votes. 5. **Discuss and prioritize** the selected items relative to each other. If there is difficulty in reaching agreement, remove the items that received the fewest votes from the list and then conduct another vote. Expertise: 1		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
			Resources: none		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
Murphy Diagrams	Stanton N, Salmon P, Walker G, et al. Process charting methods. Human factors methods: a practical guide for engineering and design. Great Britain: Ashgate; 2005. p. 109-37.	Murphy diagrams are based on the notion that 'if anything can go wrong, it will go wrong'. The method is very similar to fault tree analysis in that errors or failures are analyzed in terms of their potential causes. Murphy diagrams use the following eight behavior categories: 1. Activation/Detection 2. Observation and data collection 3. Identification of system state Interpretation of situation Task definition/selection of goal state Evaluation of alternative strategies Procedure selection Procedure execution The Murphy diagram begins with the top event being split into success and failure nodes. The analyst begins by describing the failure event under analysis. Next the 'failure' outcome is specified and the sources of the error that have an immediate effect are denied. These are called the proximal sources of error. The analyst then takes each proximal error source and breaks it down further so that the causes of the proximal error sources are defined. These proximal error causes are termed the distal causes.	1. **Define task/scenario under analysis**. The first step in a Murphy Diagram analysis is to define the task or scenario under analysis. Although typically used in the retrospective analysis of incidents, it is feasible that the method could be used proactively to predict potential failure events and their causes. 2. **Data collection**. If the analysis is retrospective, then data regarding the incident under analysis should be collected. This may involve the interviews with the actors involved in the scenario, or a walkthrough of the event. If the analysis is proactive, and concerns an event that has not yet happened, then walkthroughs of the events should be used. 3. **Define error events**. Once sufficient data regarding the event under analysis is collected, the analysis begins with the definition of the first error. The analyst(s) should define the error as clearly as possible. 4. **Classify error activity into decisionmaking**	Pros: • Easy method to use and learn, requiring little training • Murphy diagrams present a useful way for the analyst to identify a number of different possible causes for a specific error or event • High documentability • Each task step failure is exhaustively described, including proximal and distal sources • The method has the potential to be applied to team-based tasks, depicting teamwork and failures with multiple team-based causes • Murphy diagrams use very little resources (low cost, time spent, etc.) • Although developed for the retrospective analysis of error, it is feasible that the method could be used proactively Cons: • Its use as a predictive tool remains largely unexplored • Could become large and unwieldy for large, complex tasks • There is little guidance for the analyst • Consistency of the method can be questioned • Design remedies are based entirely upon the analyst's subjective judgment • Dated method that appears to be little used	

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		Used: • For the retrospective analysis of failure events	**category**. Once the error event under analysis is described, the activity leading up to the error should be classified into one of the eight decisionmaking process categories. 5. **Determine error consequence and causes**. Once the error is described and classified, the analyst(s) should determine the consequences of the error event and also determine possible consequences associated with the error. The error causes should be explored fully, with proximal and distal sources described. 6. **Construct Murphy diagram**. Once the consequences, proximal and distal sources have been explored fully, the Murphy diagram for the error in question should be constructed. 7. **Propose design remedies**. For the purpose of error prediction in the design of systems, it is recommended that the Murphy diagram be extended to include an error or design remedy column. The analyst(s) should use this column to propose design		

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			remedies for the identified errors, based upon the causes identified. Expertise: 2 Resources: none		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
NASA Task Load Index (NASA TLX)	Stanton N, Salmon P, Walker G, et al. Mental workload assessment method. Human factors methods: a practical guide for engineering and design. Great Britain: Ashgate; 2005. p. 301-64. NASA. NASA TLX: Task load index. 2006. Available at: http://humansystems.arc.nasa.gov/groups/TLX/. Accessed March 4, 2010.	The NASA Task Load Index (NASA TLX) is a subjective mental workload (MWL) assessment tool that is used to measure participant MWL during task performance. The NASA TLX is a multi-dimensional rating tool that is used to derive an overall workload rating based upon a weighted average of six workload sub-scale ratings. The TLX uses the following six sub-scales: 1. *Mental demand*. How much mental demand and perceptual activity was required (e.g. thinking, deciding, calculating, remembering, looking searching etc)? Was the task easy or demanding, simple or complex, exacting or forgiving? 2. *Physical demand*. How much physical activity was required e.g. pushing, pulling, turning, controlling, activating etc.? Was the task easy or demanding, slow or brisk, slack or strenuous, restful or laborious? 3. *Temporal demand*. How much time pressure did you feel due to the rate or pace at which the tasks or task elements occurred? Was the pace slow and leisurely or rapid and frantic? 4. *Effort*. How hard did you have to work (mentally and physically) to accomplish your level of performance?	1. **Define task(s)**. The first step in a NASA-TLX analysis is to define the tasks that are to be subjected to analysis. The types of tasks analyzed are dependent upon the focus of the analysis. 2. (Optional) **Conduct a HTA for the task(s) under analysis**. Once the task(s) under analysis are defined clearly, a HTA should be conducted for each task. This allows the analyst(s) and participants to understand the task(s) fully. 3. **Selection of participants**. Once the task(s) under analysis are clearly defined and described, it may be useful to select the participants that are to be involved in the analysis. This may not always be necessary and it may suffice to simply select participants randomly on the day. However, if workload is being compared across rank or experience levels, then clearly effort is required to select the appropriate participants. 4. **Brief participants**. Before the task(s) under	Pros: • Provides a quick and simple technique for estimating operator workload • Sub-scales are generic, so the technique can be applied to any domain • The software is available free online • Has been tested thoroughly in the past and has also been the subject of a number of validation studies e.g. • The provision of the TLX software package removes most of the work for the analyst, resulting in a very quick and simple procedure • For those without computers, the TLX is also available in a pen and paper format • A number of studies have shown its superiority over the SWAT technique • When administered post-trial the approach is non-intrusive to primary task performance Cons • When administered online, the TLX can be intrusive to primary task performance • When administered after the fact, participants may have forgotten high workload aspects of the task • Workload ratings may be correlated with task performance e.g. subjects who performed poorly on the primary task may rate their workload as very high and vice versa	

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		5. *Performance*. How successful do you think you were in accomplishing the goals of the task set by the analyst (or yourself)? How satisfied were you with your performance in accomplishing these goals? 6. *Frustration level* How insecure, discouraged, irritated, stressed and annoyed versus secure, gratified, content, relaxed and complacent did you feel during the task? Each sub-scale is presented to the participants either during or after the experimental trial and they are asked to rate their score on an interval scale ranging from low (1) to high (20). The TLX also employs a paired comparisons procedure. This involves presenting 15 pairwise combinations to the participants and asking them to select the scale from each pair that has the most effect on the workload during the task under analysis. This procedure accounts for two potential sources of between-rater variability; differences in workload definition between the raters and also differences in the sources or workload between he tasks. Used: • To evaluate the amount of	analysis are performed, all of the participants involved should be briefed regarding the purpose of the study and the NASA-TLX technique. It is recommended that participants are given a workshop on MWL and MWL assessment. It may also be useful at this stage to take the participants through an example NASA-TLX application, so that they understand how the technique works and what is required of them as participants. 5. **Performance of task under analysis**. Next, the participant(s) should perform the task under analysis. The NASA TLX can be administered either during or post-trial. However, it is recommended that the TLX is administered post-trial as online administration is intrusive to primary task performance. If on-line administration is required, then the TLX should be administered and responded to verbally. Free computer and pencil/paper versions of the NASA TLX are available at	• The sub-scale weighting procedure is laborious and adds more time to the procedure	

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		workload on a person doing a certain task • Extensively as a subjective mental workload assessment	http://humansystems.arc.nasa.gov/groups/TLX/. 6. **Weighting procedure**. When the task under analysis is complete, the weighting procedure can begin. The WEIGHT software presents 15 pair-wise comparisons of the six sub-scales (mental demand, physical demand, temporal demand, effort, performance and frustration level) to the participant. The participants should be instructed to select from each of the fifteen pairs, the sub-scale from each pair that contributed the most to the workload of the task. The WEIGHT software then calculates the total number of times each sub-scale was selected by the participant. Each scale is then rated by the software based upon the number of times it is selected by the participant. This is done using a scale of 0 (not relevant) to 5 (more important than any other factor). 7. **NASA-TLX rating procedure**. Participants should be presented with the interval scale for each of the TLX sub-		

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			scales (this is done via the RATING software). Participants are asked to give a rating for each sub-scale, between 1 (Low) and 20 (High), in response to the associated sub-scale questions. The ratings provided are based entirely on the participants' subjective judgment. 8. **TLX score calculation**. The TLX software is then used to compute an overall workload score. This is calculated by multiplying each rating by the weight given to that sub-scale by the participant. The sum of the weighted ratings for each task is then divided by 15 (sum of weights). A workload score of between 0 and 100 is then derived for the task under analysis. Expertise: 2 Resources: computer and internet access		

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Needs Assessment	Leigh D. Needs assessments: A step-by-step approach. In: Roberts A, Yeager K, editors. Evidence-based practice manual: research and outcome measures in health and human services. New York: Oxford University Press; 2004. p. 622-7. Adams J, Culp L. Needs assessment. In: Walker J, Bieber E, Richards F, editors. Implementing an electronic health record system. London: Springer; 2005. p. 9-14.	Needs assessment provides a means for providing clear direction in selecting the right solutions to the challenges and opportunities at hand, while building shared commitment to an organization's future direction. It is a formal process that identifies needs as gaps in results between what is and what should be, prioritizes those needs on the basis of the costs and benefits of closing versus ignoring those gaps in results, and selects the needs to be reduced and eliminated. Needs assessments identify gaps between current and desired results that occur both within and outside an organization in order to provide useful information for decisionmaking. A systematic process to develop an accurate understanding of the strengths and weaknesses of a business process in terms of efficiency and quality. Used: • To set and prioritize goals • To develop a plan • To allocate resources through an organized approach • Helps avoid pitfalls such as missed deadlines, budget	1. Preassessment: Leadership and team selected 2. **Scoping**: **Agree on scope and use** of needs assessment. Identify primary clients and stakeholders to whom organizational results are delivered and from whom results data are to be collected. Specify questions to be answered by assessment. 3a. **Identifying What Is: Review data currently available**. Determine required data not available and methods to collect this data. Prepare data collection plan. 3b. Identifying What Should Be: Identify required or what-should-be results. 4. **Analyzing Causes of What Is: Identify underlying causes** for results currently being achieved by organization. SWOT analysis is recommended. 5. **Analyzing Performance Requirements: Further clarifies results** of step 3b as measurable objectives, or performance requirements, at the	Pros: • Provides decisionmakers necessary data for selecting solutions, tools, and interventions that have greatest probability of accomplishing results that are beneficial internally & externally • Provides solutions to challenges at hand Cons: • Time consuming	Walker J, Bieber E, Richards F, et al. Appendix 2: Physician reporting and digital storage system needs assessment—endoscopy suite. In: Walker J, Bieber E, Richards F, editors. Implementing an electronic health record system. London: Springer; 2005. p. 183-91.

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		over-runs, etc.	Mega, Macro, and Micro levels. 6. **Analyzing Solutions Requirements: Consider current solutions** and explore new alternatives for resolving existing problems and capitalizing on new opportunities. 7. Prioritizing and Selecting Needs: Prioritize and select needs for closure, monitoring, or abandonment. 8. **Postassessment: Write a comprehensive report** of project and its findings, preparing evaluation and performance improvement plans, and determining next steps. Expertise: 2 Resources: none		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
Nominal Group Technique (NGT)	Lighter D. Process orientation in health care quality. In: Moore C, editor. Quality management in health care: principles and methods. 2 ed. Sudbury, MA: Jones and Bartlett Publishers; 2004. p. 43-101. Tague N. The tools. In: O'Mara P, editor. The quality toolbox. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2005. p. 93-521. Bauer J, Duffy G, Westcott R, editors. The quality improvement handbook, Improvement Tools. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2006. p. 109-48. Andersen B. Tools for generating ideas and choosing among them. In: O'Mara P, editor. Business process improvement toolbox. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2007. p. 157-66. Mycoted. Creativity and innovation techniques. 2009. Available at: http://www.mycoted.com/Category:Creativity_Techniques. Accessed August	Method for brainstorming in groups that have dominant members or when the group is unusually reticent to deal with an issue. The NGT provides the means by which all group members can participate in a modified brainstorming exercise. Nominal group technique (NGT) is a structured method for group brainstorming that encourages contributions from everyone. The nominal group technique (NGT) is a structured process that identifies and ranks major problems or issues that need addressing. It can be used to identify the major strengths of a department/unit/institution or to make decisions by consensus when selecting problem solutions in a business. This technique provides each participant with an equal voice. The intention of nominal group technique (NGT) is to render possible a brainstorming session where all participants have the same vote when selecting solutions. Used: • When some group	1. **State the subject** of the brainstorming. Clarify the statement as needed until everyone understands it. 2. Each team member **silently thinks of and writes down as many ideas as possible**, for a set period of time (5 to 10 min). 3. **The team is polled**, with each member presenting one idea at a time, until all ideas are recorded on a flip chart. During this time, no discussion is allowed, and team members can present ideas that are not on their lists; however, each member has a turn in the process. A member may “pass” his or her turn, and may then add an idea on a subsequent turn. Continue around the group until all members pass or for an agreed-upon length of time. 4. **Discuss each idea in turn**. Wording may be changed only when the idea’s originator agrees. Ideas may be stricken from the list only by unanimous agreement. Discussion may clarify meaning, explain logic or analysis, raise and answer	Pros: • An excellent alternative to brainstorming in situations where team interactions are more reserved and creativity needs encouragement • Empowers everyone to contribute	

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	24, 2009.	members are much more vocal than others • When having trouble generating new ideas • In groups that have dominant members • When group is avoiding a problematic issue • To help organize ideas into a more manageable form • When some group members think better in silence • When there is concern about some members not participating • When the group does not easily generate quantities of ideas • When all or some group members are new to the team • When the issue is controversial or there is heated conflict	questions, or state agreement or disagreement. 5. **Prioritize the ideas** using multivoting or list reduction. 1. The problem is presented, as in the other techniques, in a "where, what, or how" format. 2. Each group member writes down as many ideas as possible in a 10-minute period. 3. The team is polled, with each member presenting one idea at a time, until all ideas are recorded on a flip chart. During this time, no discussion is allowed, and team members can present ideas that are not on their lists; however, each member has a turn in the process. 4. If team members pass on one turn, they may add another idea during the next time around the group. 5. The process continues until all team members pass or a time limit is reached. 6. The ideas are then combined or clarified through group discussion. If an idea is to be changed, anyone		

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			contributing to the idea must agree to the change. 1. State the subject of the brainstorming. Clarify the statement as needed until everyone understands it. 2. Each team member silently thinks of and writes down as many ideas as possible, for a set period of time (5 to 10 min). 3. Each team member in turn states aloud one idea. Facilitator records it on the flipchart. No discussion is allowed, not even questions for clarification. Ideas given do not need to be from the team member's written list. Indeed, as time goes on, many ideas will not be. A member may "pass" his or her turn, and may then add an idea on a subsequent turn. Continue around the group until all members pass or for an agreed-upon length of time. 4. Discuss each idea in turn. Wording may be changed only when the idea's originator agrees. Ideas may be stricken from the list only by unanimous agreement. Discussion may clarify		

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			meaning, explain logic or analysis, raise and answer questions, or state agreement or disagreement. 5. Prioritize the ideas using multivoting or list reduction. 1. Request that all participants (usually 5 to 10 persons) write or say which problem or issue they feel is most important. 2. Record all the problems or issues. 3. Develop a master list of the problems or issues. 4. Generate and distribute to each participant a form that numbers the problems or issues in no particular order. 5. Request that each participant rank the top five problems or issues by assigning five points to their most important perceived problem and one point to the least important of their top five. 6. Tally the results by adding the points for each problem or issue. 7. The problem or issue with the highest number is the most important one for the team as a whole.		

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			8. Discuss the results and generate a final ranked list for process improvement action planning. 1. As in Brainwriting, the first step is written idea production, where each person generates ideas and writes these on idea cards, one idea per card. 2. All the produced ideas are registered on a flip chart and the ideas are briefly discussed. The purpose is to clarify the content of each idea as well as eliminate similar ideas. At the end of this stage, each idea is assigned a letter, starting with "A." 3. The next step is again an individual activity, where participants rank the ideas. From the complete list of ideas, each participant selects up to five ideas and writes these on his or her ranking card. Each idea is identified by its assigned letter form the list on the flip chart. When ranking ideas, participants assign points to the ideas—from 5 for the most important or best idea down to 1 for the least important or worst idea.		

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			4. The session leader collects the ranking cards and writes the assigned points on the flip chart. For each idea, the points are summarized to total scores. The idea achieving the highest total score is the group's prioritized idea or solution. Expertise: 1 Resources: flip chart		
Observation	National Science Foundation. Common qualtative methods. Overview of Qualitative Methods and Analytic Techniques 1997.	Observational techniques are methods by which an individual or individuals gather firsthand data on programs, processes, or behaviors being studied.		Pros: • Provide direct information about behavior of individuals and groups • Permit evaluator to enter into and understand	

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
	Available at: http://www.nsf.gov/pubs/1997/nsf97153/chap_3.htm. Accessed 2010 June 28, 2010.	They provide evaluators with an opportunity to collect data on a wide range of behaviors, to capture a great variety of interactions, and to openly explore the evaluation topic. By directly observing operations and activities, the evaluator can develop a holistic perspective, i.e., an understanding of the context within which the project operates. This may be especially important where it is not the event that is of interest, but rather how that event may fit into, or be impacted by, a sequence of events. Observational approaches also allow the evaluator to learn about things the participants or staff may be unaware of or that they are unwilling or unable to discuss in an interview or focus group. Used: • During both the formative and summative phases of evaluation • To gain an understanding of behaviors and interactions between people and/or IT		situation/context • Provide good opportunities for identifying unanticipated outcomes • Exist in natural, unstructured, and flexible setting Cons: • Can be expensive and time consuming • Need well-qualified, highly trained experts; may need to be content experts • May affect behavior of participants • Selective perception of observer may distort data • Investigator has little control over situation • Behavior or set of behaviors may be atypical	

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
Operation Sequence Diagrams (OSD)	Stanton N, Salmon P, Walker G, et al. Process charting methods. Human factors methods: a practical guide for engineering and design. Great Britain: Ashgate; 2005. p. 109-37.	Operation Sequence Diagrams (OSD) are used to graphically describe the activity and interaction between teams of agents within a network. The output of an OSD graphically depicts the task process, including the tasks performed and the interaction between operators over time, using standardized symbols. Used: • To graphically describe the activity and interaction between teams of agents within a network	1. DEFINE THE TASK(S) UNDER ANALYSIS. The first step in an OSD analysis is to define the task(s) or scenario(s) under analysis. The task(s) or scenario(s) should be defined clearly, including the activity and agents involved. 2. DATA COLLECTION. In order to construct an OSD the analyst(s) must obtain specific data regarding the task or scenario under analysis. It is recommended that the analyst(s) use various forms of data collection in this phase. Observational study should be used to observe the task (or similar type or task under analysis. Interviews with personnel involved in the task (or similar tasks) should also be conducted. The type and amount of data collected in step 2 is dependent upon the analysis requirements. The more exhaustive the analysis is intended to be, the more data collection methods should be employed. 3. DESCRIBE THE TASK OR SCENARIO USING HIERARCHICAL	Pros: • The OSD provides an exhaustive analysis of the task in question • An OSD is particularly useful for analyzing and representing distributed teamwork or collaborated activity • OSDs are useful for demonstrating the relationship between tasks, technology and team members • High face validity • OSDs have been used extensively in the past and have been applied in a variety of domains • A number of different analyses can be overlaid onto an OSD of a particular task • The OSD method is very flexible and can be modified to suit the analysis needs • The WESTT software package can be used to automate a large portion of the OSD procedure • Despite its exhaustive nature, the OSD method requires only minimum training Cons: • The application time for an OSD analysis is lengthy. Constructing an OSD for large complex tasks can be extremely time consuming and the initial data collection adds further time to the analysis.	

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			TASK ANALYSIS (HTA). Once the data collection phase is completed, a detailed task analysis should be conducted for the scenario under analysis. The type of task analysis is determined by the analyst(s), and in some cases, a task list will suffice. However, it is recommended that a HTA is conducted for the task under analysis. 4. Once the task has been described adequately, the CONSTRUCTION OF THE OSD can begin. The process begins with the construction of an OSD template. The template should include the title of the task or scenario under analysis, a timeline, and a row for each agent involved in the task. In order to construct the OSD, it is recommended that the analyst walks thorough the HTA of the task under analysis, creating the OSD in conjunction. The symbols involved in a particular task step should be linked by directional arrows, in order to represent the flow of activity during the scenario. Each symbol in the OSD	• The construction of large, complex OSDs is also quite a laborious and taxing process • OSDs can become cluttered and confusing • The output of OSDs can become large and unwieldy • The present OSD symbols are limited for certain applications • The reliability of the method is questionable. Different analysts may interpret the OSD symbols differently	

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			should contain the corresponding task step number from the HTA of the scenario. The artifacts used during the communications should also be annotated on to the OSD. 5. OVERLAY ADDITIONAL ANALYSES RESULTS. One of the endearing features of the OSD method is that additional analysis results can easily be added to the OSD. According to the analysis requirements, additional task features can also be annotated onto the OSD. 6. CALCULATE OPERATION LOADING FIGURES. From the OSD, operational loading figures are calculated for each agent involved in the scenario under analysis. Operational loading figures are calculated for each OSD operator or symbol used e.g. operation, receive, delay, decision, transport, and combined operations. The operational loading figures refer to the frequency in which each agent was involved in the operator in question during the scenario.		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
			Resources: none Expertise: 2		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
Pareto Chart (Also called: Pareto diagram, Pareto analysis)	American Society for Quality. Cause analysis tools: Pareto chart. 2009. Available at: http://www.asq.org/learn-about-quality/cause-analysis-tools/overview/pareto.html. Accessed June 26, 2009. University Research Co. LLC. Quality Assurance Project: Pareto chart. 2008. Available at: http://www.qaproject.org/methods/resparetochart.html. Accessed July 28, 2009. Besterfield D. Total quality management—Tools and techniques. In: Krassow E, editor. Quality Control. 8th ed. Upper Saddle River, NJ: Pearson Prentice Hall; 2009. p. 77-115. George M, Rowlands D, Price M, et al. Identifying and verifying causes. The lean six sigma pocket toolbook. New York: McGraw–Hill; 2005. p. 141-96. Tague N. The tools. In: O'Mara P, editor. The quality toolbox. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2005. p. 93-521.	A Pareto chart is a bar graph. The lengths of the bars represent frequency or cost (time or money), and are arranged with longest bars on the left and the shortest to the right. In this way the chart visually depicts which situations are more significant. The Pareto principle states that most of the effects, often around 80%, are from a small number of causes, often only 20%. Even more importantly, 80% of all costs connected to poor quality or generally low performance is from 20% of all possible causes. The Pareto chart is a tool used to graphically display this skewed distribution, the 80-20 rule. A Pareto chart provides facts needed for setting priorities. It organizes and displays information to show the relative importance of various problems or causes of problems. It is essentially a special form of a vertical bar chart that puts items in order (from the highest to the lowest) relative to some measurable effect of interest: frequency, cost, time. The chart is based on the *Pareto* principle, which states that when several factors affect a situation, a few factors will account for	1. DEVELOP A LIST of problems, items, or causes to be compared. 2. DEVELOP A STANDARD MEASURE for comparing the items. 3. Define the time period during which to collect data about the potential causes (days, weeks, or as much time as is required to observe a significant number of occurrences). 4. TALLY, FOR EACH ITEM, HOW OFTEN IT OCCURRED (or cost or total time it took). Then add these amounts to determine the grand total for all items. Find the percent of each item in the grand total by taking the sum of the item, dividing it by the grand total, and multiplying by 100. 5. LIST THE ITEMS being compared in decreasing order of the measure of comparison: e.g., the most frequent to the least frequent. The cumulative percent for an item is the sum of that item's percent of the total and that of all the other items that come before it in the ordering by rank. 6. LIST THE ITEMS on the horizontal axis of a graph from highest to	Pros: • Shows problems that are most important • Shows the problems that appear to account for most of the variation • Can easily be constructed using standard spreadsheet software • Prioritizes actions needed to solve complex problems • Sorts out the "vital few" from the "trivial many" • Separates important from unimportant causes contributing to a problem • Measures improvement after changes have been made	Holst T. Improving first-case OR start times by utilizing six sigma methodologies. 2007 Society for Health Systems Conference; 2007; New Orleans, LA; 2007.

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
	Bauer J, Duffy G, Westcott R, editors. The quality improvement handbook, Improvement Tools. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2006. p. 109-48. Andersen B. Tools for analyzing the performance shortcoming. In: O'Mara P, editor. Business process improvement toolkit. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2007. p. 123-55. The Boeing Company. Advanced quality system tools. 1998. Available at: http://www.boeing.com/companyoffices/doingbiz/supplier/d1-9000-1.pdf. Accessed August 24, 2009. Mind Tools Ltd. Pareto analysis. 2009. Available at: http://www.mindtools.com/pages/article/newTED_01.htm. Accessed August 24, 2009. Tidd J, Bessant J, Pavitt K. Innovation management toolbox. 2001. Available at: http://www.wiley.co.uk/wil	most of the impact. The Pareto principle describes a phenomenon in which 80 percent of variation observed in everyday processes can be explained by a mere 20% of the causes of that variation. A Pareto diagram is a graph that ranks data classifications in descending order from left to right. They are used to identify the most important problems. Usually, 80% of the total results from 20% of the items. Pareto charts are a type of bar chart in which the horizontal axis represents categories rather than a continuous scale. The categories are often defects, errors or sources (causes) of defects/errors. The height of the bars can represent a count or percent of errors/defects or their impact in terms of delays, rework, cost, etc. By arranging the bars from largest to smallest, a Pareto chart can help you determine which categories will yield the biggest gains if addressed and which are only minor contributors to the problem. A Pareto chart is a graphic representation of the frequency with which certain events occur. It is a rank-	lowest. Label the left vertical axis with the numbers (frequency, time, or cost), then label the right vertical axis with the cumulative percentages (the cumulative total should equal 100%). Draw in the bars for each item. 7. DRAW A LINE GRAPH of the cumulative percentages. The first point on the line graph should line up with the top of the first bar. 8. ANALYZE THE DIAGRAM by identifying those items that appear to account for most of the difficulty. Do this by looking for a clear breakpoint in the line graph, where it starts to level off quickly. If there is not a breakpoint, identify those items that account for 50% or more of the effect. If there appears to be no pattern (the bars are essentially all of the same height), think of some factors that may affect the outcome, such as day of week, shift, age group of patients, home village. Then, subdivide the data and draw separate Pareto charts for each subgroup to see if a		

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	eychi/innovate/website/pages/atoz/atoz.htm. Accessed August 24, 2009.	order chart that displays the relative importance of variables in a dataset and may be used to set priorities regarding opportunities for improvement. Pareto charts are bar charts, prioritized in descending order from left to right, used to identify the vital few opportunities for improvement. It shows where to put your initial effort to get the most gain. The Pareto principle states that most of the effects, often around 80%, are from a small number of causes, often only 20%. Even more importantly, 80% of all costs connected to poor quality or generally low performance is from 20% of all possible causes. The Pareto chart is a tool used to graphically display this skewed distribution, the 80-20 rule. The chart shows the causes of a problem sorted by the degree of seriousness and expressed as frequency of occurrence, costs, performance level, and so on. The causes are sorted by placing the most severe on the left side of the chart, rendering quite easy to identify the vital few. To enable portraying additional information in the chart, it is common to include a curve showing cumulative importance.	pattern emerges. 1. Decide what categories will use to group items. 2. Decide on measurement (frequency, quantity, cost, time, etc.) 3. Decide period of time (work cycle, day, week, etc.) 4. Collect data, recording category each time. 5. Subtotal measurements for each category. 6. Determine appropriate scale for measurements collected. 7. Construct and label bars for each category. 8. Calculate percentage for each category. 9. Calculate and draw cumulative sums. *Pareto chart template in ASQ 1. Develop a list of problems, items, or causes to be compared. 2. Develop a standard measure for comparing the items. 3. Choose a time frame for collecting the data. 4. Tally, for each item, how often it occurred (or cost or total time it took).		

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		A bar chart where the bars are arranged in descending order of magnitude. The bars may represent defect categories, locations, departments, and so on. The magnitude (length) of the bars may represent frequencies, percentages, costs, or times. Pareto analysis is a very simple technique that helps you to choose the most effective changes to make. It uses the Pareto principle—the idea that by doing 20% of work you can generate 80% of the advantage of doing the entire job*. Pareto analysis is a formal technique for finding the changes that will give the biggest benefits. It is useful where many possible courses of action are competing for your attention. Used: • When analyzing data about the frequency of problems or causes in a process. • When there are many problems or causes and you want to focus on the most significant. • When analyzing broad causes by looking at their specific components. • When communicating with others about your data. • To help teams focus on	Then add these amounts to determine the grand total for all items. Find the percent of each item in the grand total by taking the sum of the item, dividing it by the grand total, and multiplying by 100. 5. List the items being compared in decreasing order of the measure of comparison: e.g., the most frequent to the least frequent. The cumulative percent for an item is the sum of that item's percent of the total and that of all the other items that come before it in the ordering by rank. 6. List the items on the horizontal axis of a graph from highest to lowest. Label the left vertical axis with the numbers (frequency, time, or cost), then label the right vertical axis with the cumulative percentages (the cumulative total should equal 100%). Draw in the bars for each item. 7. Draw a line graph of the cumulative percentages. The first point on the line graph should line up with the top of the first bar. 8. Analyze the diagram by identifying those		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
		small number of really important problems or causes of problems • To identify problems and measure progress • To separate the few major problems from the many possible problems in order to focus improvement efforts • To arrange data according to priority or importance • To determine which problems are the most important using data, not perception • When many factors contribute to a problem • When attention needs to be directed only to the few facts that account for most of the problem • When analyzing the results of a risk analysis	items that appear to account for most of the difficulty. Do this by looking for a clear breakpoint in the line graph, where it starts to level off quickly. If there is not a breakpoint, identify those items that account for 50% or more of the effect. If there appears to be no pattern (the bars are essentially all of the same height), think of some factors that may affect the outcome, such as day of week, shift, age group of patients, home village. Then, subdivide the data and draw separate Pareto charts for each subgroup to see if a pattern emerges. 1. Determine the method of classifying the data: by problem, cause, type of nonconformity, etc. 2. Decide if dollars, weighted frequency, or frequency is to be used to rank the characteristics. 3. Collect data for an appropriate time interval. 4. Summarize the data and rank-order categories from largest to smallest.		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
			5. Compute the cumulative percentage if it is to be used. 6. Construct the diagram and find the vital few. 1. Collect data on different types or categories of problems. 2. Tabulate the scores. Determine the total number of problems observed and/or the total impact. Also determine the counts or impact for each category. 3. Sort the problems by frequency or by level of impact. 4. Draw a vertical axis and divide into increments equal to the total number you observed. 5. Draw bars for each category, starting with the largest and working down. 6. Add in the cumulative percentage line. 7. Interpret the results. 1. Define the measurement scale for the potential causes. (this is usually the frequency of occurrence or cost.) 2. Define the time period during which to collect data about the potential		

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			causes (days, weeks, or as much time as is required to observe a significant number of occurrences). 3. Collect and tally data for each potential cause. 4. Label the horizontal (x) axis with all the possible root causes in descending order of value. 5. Label the measurement scale on the vertical (y) axis. 6. Draw one bar for each possible cause to represent the value of the measurement. 7. If desired, add a vertical (y) axis on the right side of the chart to represent cumulative percentage values. 8. Draw a line to show the cumulative percentage from left to right as each cause is added to the chart. 1. Define the performance shortcoming and the potential causes of it. 2. Decide which quantitative measure to use when comparing the possible causes. As has been mentioned, this measure might be how often the different problems occur or consequences of them		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
			in terms of cost or other conditions. 3. Using existing data or collect the necessary data. 4. Place the causes from left to right along the horizontal axis in descending relative importance. Draw rectangles of heights that represent this importance. 5. Mark the data value on the left vertical axis and the percentage value on the right, and draw the curve for cumulative importance along the top edge of the rectangles. 1. Identify the problem and the time period for the study. 2. Define the types of data to be analyzed (e.g., defects, locations). 3. Define the form of measurement to be used (e.g., frequency, percentage). 4. Collect representative data and categorize. 5. Count and arrange the data in descending order. 6. If possible, assign costs to each category, multiply frequency by cost, and reprioritize. 7. Make a bar chart of the data and clearly		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
			label categories. 8. Analyze results and prepare improvement activities for “vital few.” Resources: spreadsheet software Expertise: 1		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
Plan–Do–Check–Act (PDCA) Cycle (Also called: plan–do–study–act (PDSA) cycle, Deming cycle, Shewhart cycle)	American Society for Quality. Project planning and implementing tools: Plan-Do-Check-Act Cycle. 2009. Available at: http://www.asq.org/learn-about-quality/project-planning-tools/overview/pdca-cycle.html. Accessed 2009 July 23, 2009. Yeager K. Program evaluation: This is rocket science. In: Roberts A, Yeager K, editors. Evidence-based practice manual: research and outcome measures in health and human services. New York: Oxford University Press; 2004. p. 647-53. Silimperi D, Zanten V, Franco L. Framework for institutionalizing quality assurance. In: Roberts A, Yeager K, editors. Evidence-based practice manual: research and outcome measures in health and human services. New York: Oxford University Press; 2004. p. 867-81. Tague N. The tools. In: O'Mara P, editor. The quality toolbox. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2005. p. 93-521.	The plan–do–check–act (PDCA) cycle is a four-step model for carrying out change, problem solving, and continuous improvement. Just as a circle has no end, the PDCA cycle should be repeated again and again for continuous improvement. The PDCA cycle is a four-step model for carrying out change. Just as a circle has no end, the PDCA cycle should be repeated again and again for continuous improvement. In quality improvement in health care and human services, the process for experimentation with a process is the PDCA cycle described by Walter Shewhart and W. Edwards Deming, essentially an iteration of the scientific method (Deming, 1986; Yeager, 2002) Promotes continuous improvement as hypotheses are created, tested, revised, and implemented, only to be adapted in the next cycle of learning The PDCA cycle is a systematic approach and discipline to problem solving and continuous improvement. It is often	1. Plan: Recognize an opportunity and plan a change 2. Do: Test the change. Carry out a small-scale study. 3. Study: Review the test, analyze the results and identify what you've learned. 4. Act: Take action based on what you learned in the study step. If the change was unsuccessful, repeat the cycle with a different plan. If the change was successful, incorporate what you learned from the test into wider changes. 1. In the planning stage, the problem is recognized and analyzed, and possible solutions formulated. 2. In the doing stage, the most likely or effective solution is implemented in a test site. 3. The checking stage is used to compare results of the test solution and the original method. 4. The acting stage involves replacing the old method with the successful solution. 1. PLAN—A conjecture or change for	Pros: • Is a guide to overall process improvement • Can and should be used with other process improvement tools • Stimulates creative and analytic thinking • Provides a systematic method for improvement • Provides a common format and process that various groups in an organization can follow • Ensures that all steps in a problem solving or improvement situation are followed, resulting in valid, effective and efficient solutions • Brings order to often meandering problem-solving efforts • Provides feedback for further improvement	

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
	The Boeing Company. Advanced quality system tools. 1998. Available at: http://www.boeing.com/companyoffices/doingbiz/supplier/d1-9000-1.pdf. Accessed August 24, 2009.	conceptually drawn as a wheel showing the feedback nature of the process. In practice, the steps for a process being studied are usually drawn linearly, but still follow the PDCA cycle. Used: • As a model for continuous improvement • When starting a new improvement project • When developing a new or improved design of a process, product or service • When defining a repetitive work process • When planning data collection and analysis in order to verify and prioritize problems or root causes • When implementing any change • When embarking on problem-solving activities	improvement is planned. 2. DO—Execute or test the conjecture or change (often on a small scale). 3. CHECK—Gather and analyze data to observe the effect of the change and to see if the change worked. 4. ACT—Implement the process improvement if the results are good or reassess and try an alternative approach by repeating the cycle with the information accumulated. Resources: none Expertise: 1		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
Political, Economic, Social and Technological Forces (PEST) Analysis	Medical Group Management Association. PEST analysis. Englewood, CO; 2005. Mind Tools Ltd. PEST analysis. 2009. Available at: http://www.mindtools.com/pages/article/newTMC_09.htm. Accessed August 24, 2009.	The Political, Economic, Social and Technological Forces (PEST) analysis is a simple tool to identify environmental factors that may influence key strategies in your organization. This powerful analysis helps you assess four key variables of your macro-environment: 1. Political forces 2. Economic forces 3. Social forces 4. Technological forces PEST Analysis is a simple, useful and widely-used tool that helps you understand the "big picture" of your **P**olitical, **E**conomic, **S**ocio-Cultural and **T**echnological environment. As such, it is used by business leaders worldwide to build their vision of the future. By making effective use of PEST Analysis, you ensure that what you are doing is aligned positively with the powerful forces of change that are affecting our world. By taking advantage of change, you are much more likely to be successful than if your activities oppose it. Good use of PEST Analysis helps you avoid taking action that is doomed to failure from the outset, for reasons beyond your control. PEST is useful when you start operating in a new country or region. Use of PEST	Key problems are identified and simply listed in a grid. However, it is recommended that you not only list each environmental force, but also note the potential impact of that problem on your medical practice. These implications may identify a barrier to service access, but they may also become opportunities to enhance existing services or develop new ones. List key problems and their potential impacts on your practice in the most appropriate column. Use your list of potential problems and impacts to brainstorm your practice's responses and opportunities. * PEST analysis worksheet available on MindTools Resources: none Expertise: 1	Pros: Quick and easy tool to use	

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
		helps you break free of unconscious assumptions, and helps you quickly adapt to the realities of the new environment. Used: • To identify environmental factors that may influence key strategies in your organization			

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Potential Problem Analysis (PPA)	Tague N. The tools. In: O'Mara P, editor. The quality toolbox. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2005. p. 93-521.	Potential problem analysis systematically identifies what might go wrong in a plan under development. Problem causes are rated for their probability of occurrence and how serious their consequences are. Preventive actions are developed as well as contingency plans in case the problem occurs anyway. By using PPA, smooth implementation of a plan is more likely. Used: • Before implementing a plan • When something might go wrong • When the plan is large and complex • When the plan must be completed on schedule • When the price of failure is high	1. IDENTIFY BROAD ASPECTS of plan that are vulnerable to disruption/failure. 2. For each aspect, IDENTIFY SPECIFIC PROBLEMS that could occur. Write problems in the first column of a table. 3. For each problem, ESTIMATE ITS RISK by rating as high, medium, or low both the probability of the problem occurring and the seriousness of its consequences. Write those assessments under the problem statement. Prioritize the problems by deciding which risks you are willing to accept. For problems whose risks are unacceptable. 4. IDENTIFY POSSIBLE CAUSES, where appropriate, and write them in the second column. 5. (Optional) For each cause, RATE AS HIGH, MEDIUM, OR LOW the probability of its occurrence, recorded in a column headed P, and the seriousness of its consequences, recorded in a column headed S. 6. For each cause (or problem, if causes were	Pros: • PPA specifically addresses causes, rates risk, and separates preventive actions from contingency plans	

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
			not detailed), IDENTIFY PREVENTATIVE ACTIONS that would eliminate or reduce its chance of occurring. Write it in the fifth column. Rate the residual risk, the probability and seriousness of the cause even with the preventative action in place, and record it in the next column. 7. For each cause whose residual risk is unacceptable, DEVELOP A CONTINGENCY PLAN to minimize the consequences of the problem if the preventive action fails. Identify what should be done, who is responsible, and what trigger will set the plan into action. Record the plan in the last column Resources: none Expertise: 1		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
Process Decision Program Chart (PDPC)	American Society for Quality. Seven new management and planning tools: Process decision program chart. 2009. Available at: http://www.asq.org/learn-about-quality/new-management-planning-tools/overview/process-decision-program-chart.html. Accessed 2009 July 23, 2009. Tague N. The tools. In: O'Mara P, editor. The quality toolbox. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2005. p. 93-521. Andersen B. Tools for implementing improvements. In: O'Mara P, editor. Business process improvement toolbox. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2007. p. 237-49.	The process decision program chart systematically identifies what might go wrong in a plan under development. Countermeasures are developed to prevent or offset those problems. By using PDPC, you can either revise the plan to avoid the problems or be ready with the best response when a problem occurs. The process decision program chart (PDPC) is a planning tool for making detailed implementation plans that include all possible negative events and problems that could occur along the way. Predicting such problems before they occur makes it possible to address them. This enables some form of preemptive problem solving, which is inexpensive compared with starting to think about solutions only after the problem has occurred. The PDPC is most often used when a large and complex task is to be carried out for the first time where the costs associated with failure are exceedingly high, and where finishing by the deadline is critical. Used: • Before implementing a plan, especially when plan	1. Obtain or develop a tree diagram of proposed plan. Should have high-level diagram of objective, second level of main activities, and third level of broadly defined tasks to accomplish main activities. 2. For each task on third level, brainstorm what could go wrong. 3. Review all potential problems and eliminate any that are improbable or whose consequences are insignificant. Show problems as fourth level linked to tasks. 4. For each potential problem, brainstorm possible countermeasures. Show as fifth level outlined in clouds or jagged lines. 5. Decide how practical each countermeasure is. Use criteria such as cost, time required, ease of implementation and effectiveness. Mark impractical countermeasures with an X and practical ones with an O. 1. GENERATE A TREE DIAGRAM for the implementation task or use one that has already been designed. At least to start with, it is		

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		is large and complex • When plan must be completed on schedule • When price of failure is high • With a tree diagram	wise to use a tree diagram that is not too complicated, as this can require undue time for analyzing possible problems for small, unimportant activities. An appropriate complexity contains the main activities with one level below them. 2. For each element at the lowest level of the tree diagram, ASK QUESTIONS like, "What potential problems could occur during this activity?" and "What cold go wrong here?" For these questions, brainstorm a list of answers for each potential problem area. When no more answers surface, examine the list to eliminate problems that are unlikely or that are expected to have no significant consequences. Each element should include an assessment of the consequences in terms of time, cost, and quality. 3. ADD THE REMAINING POTENTIAL PROBLEMS, those that are considered significant, to the diagram as what-if elements below the		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
			lowest level of activities. Use a different color or shape to separate these elements from the activities. 4. For each what-if element, BRAINSTORM POSSIBLE COUNTERMEASURES that can be undertaken if the problem occurs. These countermeasures should consist of reserve activities and indications of duration and cost. Place all countermeasures in the diagram, which is being transformed form a tree diagram to a PDPC. Place the countermeasures under the what-if elements and link them to the potential problems they solve. Again, use a different color to separate them form the what-if elements and the activities. 5. Finally, EVALUATE EACH COUNTERMEASURE with regard to ease of implementation, practicality, effectiveness, and so on. Mark difficult or ineffective ones with an X, and mark those you expect to be effective with an O.		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
			Resources: none Expertise: 1		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
Process scorecard		A process scorecard evaluates a process according to a set of pre-defined criteria. Based on the user's feedback, the scorecard gives a rating for the process and often times short recommendations according to the rating the process receives. Used: • To give a grade/score on a certain process based on standards	The user(s) answer questions in the scorecard based on their experience and knowledge of the process that is being evaluated. These questions can be in several different formats: multiple choice, yes/no, checklist, short answer, etc. Resources: Need a pre-made scorecard—may be a software program. Creating a scorecard yourself can be very time consuming and biased. Scorecard should be specific to the process. Expertise: 1	Pros: • Can be completed relatively quick • Gives a quantitative result based on qualitative input • Provides immediate feedback unlike a questionnaire or survey Cons: • Can be difficult to find a scorecard specific to a certain process • Recommendations are very general • May need to be done by external auditor due to bias	National Committee for Quality Assurance. Standards and Guidelines for Physician Practice Connections®—Patient—Centered Medical Home (PPC—PCMH™) CMS Version. 2008. Available at: http://www.cms.hhs.gov/DemoProjectsEvalRpts/downloads/MedHome_PPC.pdf. Accessed May 20, 2009. Nelson R. Information technology assessment (Part I). 2003. Available at: http://www.mgma.com/WorkArea/showcontent.aspx?id=5558. Accessed July 10, 2009. Nelson R. Information technology assessment (Part II). 2003. Available at: http://www.mgma.com/WorkArea/showcontent.aspx?id=5560. Accessed July 10, 2009. Medical Group Management Association. Strategic planning self-assessment questionnaire. 2006. Available at: http://www.mgma.com/WorkArea/showcontent.aspx?id=10364. Accessed July 10, 2009.

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
Program Evaluation and Review Technique (PERT) Charts	Fox J, Black E, Chronokis I, et al. From guidelines to careflows: Modelling and supporting complex clinical processes. In: Teije A, Miksch S, Lucas P, editors. Computer-based medical guidelines and protocols: a primer and current trends. The Netherlands: IOS Press; 2008. p. 44-62. Internet Center for Management and Business Administration I. ICMBA: PERT. 2007. Available at: http://www.netmba.com/operations/project/pert/. Accessed July 22, 2009. Lighter D. Process orientation in health care quality. In: Moore C, editor. Quality management in health care: principles and methods. 2 ed. Sudbury, MA: Jones and Bartlett Publishers; 2004. p. 43-101. Tague N. The tools. In: O'Mara P, editor. The quality toolbox. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2005. p. 93-521.	A technique for managing projects to simplify planning and scheduling and is commonly used in R&D-type projects where time, rather than cost, is the major factor. PERT method accommodates some uncertainty by making it possible to schedule a project while not knowing precisely the details and durations of all the activities. Used: • For analyzing dependencies in a process and detect overruns or other problems	1. Identify the specific activities and milestones 2. Determine the proper sequence of the activities 3. Construct a network diagram 4. Estimate the time required for each activity 5. Determine the critical path 6. Update the PERT chart as the project progresses 1. DEFINE STEPS IN PROCESS. Place them in order on a flowchart. 2. DETERMINE DURATION OF EACH STEP, including shortest time and longest time necessary to complete the step. 3. CONSTRUCT THE PERT STATISTICS based on duration data, including earliest start, latest start, earliest finish, latest finish, and slack for each step. 4. COMPLETE THE BOXES IN THE PERT DIAGRAM with the numbers from the analysis in the previous step. 5. CALCULATE TOTAL TIME for the process and compare them to standards or benchmarks. 6. EVALUATE POSSIBLE INTERVENTIONS for improvement, such as those steps with the	Pros: • Accommodates some uncertainty • Contains source utilization and time Cons: • Not for actively executing or supporting the management of the process in real time • Not oriented towards personalization of care plans nor dynamic modifications of treatment plans during changing situations or unexpected events • Not for supporting routine processes • When critical path tasks are shortened, the entire network must be recalculated	

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Questionnaire for User Interface Satisfaction (QUIS)	Stanton N, Salmon P, Walker G, et al. Interface analysis methods. Human factors methods: a practical guide for engineering and design. Great Britain: Ashgate; 2005. p. 431-81.	The questionnaire for user interface satisfaction (QUIS) is a questionnaire method that is used to assess user acceptance and opinions of human-computer interfaces. The QUIS method is used to elicit subjective user opinions on all usability related aspects of an interface, including ease of use, system capability, consistency and learning. There are a number of different versions of the QUIS method available. QUIS uses questions relating to the use of human-computer interfaces. Each question has an associated rating scale, typically ascending from 1 to 10. Used: • To assess user acceptance and opinions of human-computer interfaces • To elicit subjective user opinions on all usability related aspects of an interface	1. IDENTIFY USER SAMPLE. The first step in a QUIS analysis is to identify the user sample that will be used in the analysis. It is recommended that the user sample used represents a portion of the typical users of the software system or type of software system under analysis. It may be most pertinent to use a sample of end users of the system in question. 2. DEFINE REPRESENTATIVE TASK LIST FOR THE SYSTEM UNDER ANALYSIS. Once he participant sample has been defined, the analyst(s) should develop a representative task list for the software system under analysis. This task list should be exhaustive, representing every possible task that can be performed using the system under analysis. This task list represents the set of tasks that the participants will perform during the analysis. If the task list is too great (i.e. requires more time to complete than is allowed by the scope of	Pros: • QUIS is a very quick and easy method to use, requiring only minimal training • The output of QUIS is immediately useful, offering an insight into the system users' attitudes regarding the usability of the interface under analysis • If the correct sample is used, the data obtained is potentially very powerful, offering an end user rating of system usability • Once an operational system is available, the speed, ease and usefulness of QUIS allow it to be used repeatedly throughout the design lifecycle to evaluate and modify design concepts • Encouraging reliability and validity statistics • The QUIS can be modified to suit analysis needs • Can be used effectively even with small sample sizes Cons: • QUIS is limited to the analysis of human-computer interaction (HCI) devices	

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			the analysis), then the analyst should pick as representative a set of tasks as possible. It is recommended that a hierarchical task analysis for the software system under analysis be used to develop the task list. 3. QUIS BRIEFING SESSION. Before the task performance step of the QUIS analysis, the participants should be briefed regarding the purpose of the analysis and how to complete the QUIS questionnaire. It may be useful for the analyst(s) to run through the task list and the QUIS questionnaire, explaining any statements that may cause confusion. In some cases, a demonstration of the tasks required may be pertinent. The participants should be encouraged to ask any questions regarding the completion of the QUIS questionnaire and the task list at this point. 4. TASK PERFORMANCE. Once the participant sample and task list have been defined, and the participants fully understand the tasks		

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			that they are required to perform and also how to complete the QUIS questionnaire, the task performance can begin. The participants should now be given the task list and instructed to perform, as normal, the tasks in the order that they are specified using the system under analysis. It is important that no conferring between participants takes place during the task performance, and also that no help is administered by the analyst(s). The task performance should go on as long as is required for each participant to complete the required task list. 5. ADMINISTER QUIS QUESTIONNAIRE. QUIS is normally administered post-trial. Once all of the participants have completed the task list for the software system under analysis, the QUIS questionnaire should be administered. After a brief demonstration of how to complete the QUIS questionnaire, the participants should be instructed to complete the questionnaire,		

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			basing their responses on the tasks that they have just carried out with the interface in question. Again, no conferring between participants is permitted during this step, although the analyst(s) may assist the participants with statements that they do not understand. 6. CALCULATE GLOBAL AND SUB-SCALE QUIS SCORES. Once all of the QUIS questionnaires are completed and handed in, the scoring process begins. The analyst may choose to calculate a global QUIS score and scores for each of the separate QUIS sub-scales (e.g. system capability, learning, screen, terminology and system information). These scores can then be averaged across participants in order to obtain mean scores for the system under analysis. Resources: none Expertise: 2		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
Radar Chart (Also called: Web Chart, Spider Chart, Star Chart)	Tague N. The tools. In: O'Mara P, editor. The quality toolbox. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2005. p. 93-521. Andersen B. Creating a business process improvement road map. In: O'Mara P, editor. Business process improvement toolbox. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2007. p. 75-92.	The radar chart is a graph that looks like a spiderweb, with spokes radiating from a central point and lines connecting them. It shows measurements where several variables contribute to the overall picture. All variables are considered to be of equal importance on a radar chart. The spider chart is an analysis tool offering additional capabilities for graphically displaying your performance data. It is more of a general chart type that has many applications, but in this respect, there are primarily two useful ways to employ a spider chart: • To gain a quick overview of the performance levels for a number of different performance indicators simultaneously, mainly to find which are in order and which are lagging • To compare the organization's own performance level with that of other organizations—a graphical presentation of benchmarking data Used: • When tracking or reporting performance or progress • When several variables are being measured to assess overall performance • When it is not necessary to	1. IDENTIFY THE VARIABLES that will be measured. These may come from customer requirements, key performance indicators, or organizational goals. Other quality tools such as brainstorming or affinity diagrams may be used to develop the variables, or they may have been developed at another point in the quality improvement process. 2. For each variable, DETERMINE THE MEASUREMENT SCALE. It is simplest for each to have the same scale, such as 1 to 5 or a percentage, but different scales can be used if necessary. Determine which end of the scale represents desirable performance. 3. To DRAW THE CHART, divide 360 degrees by the number of criteria to determine the angle between spokes. Draw spokes of equal lengths radiating from a central point and spaced evenly around the circle. Label each spoke with its variable. Mark the measurement scale on the spokes, with undesirable performance at the	Pros: • Work well for showing at a glance which categories need the most improvement or where progress has been made Cons: • All entries included in the chart are assigned equal weight	

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
		weight the relative importance of the variables • To gain a quick overview of the performance levels for a number of different performance indicators simultaneously, mainly to find which are in order and which are lagging • To compare the organization's own performance level with that of other organizations—a graphical presentation of benchmarking data	center. 4. For each variable, MARK ITS MEASUREMENT on the spoke with a large dot. Connect the dots. 5. To show performance at a different time or by another subject, REPEAT STEP 4, using different line styles. Add a legend or labels to identify line styles. To show performance of multiple subjects or at multiple times, draw a separate chart for each one. 6. ASSESS OVERALL PERFORMANCE and determine needed improvement by observing where the "web" lies closest to the center point. 1. Collect data from market analyses, surveys, competitor analyses, and so on. 2. Assign one variable to each spoke in the chart. 3. Divide each spoke into logical segments by using a separate unit of measurement for each variable. The farther from the center of the chart, the higher the performance. 4. Plot the performance data for each variable		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
			along the correct spokes, using different colors or symbols to separate data points from those of different organizations. 5. Draw lines between the data points for each organization to generate performance profiles. 6. Identify the variables that show the largest gaps between your organization and the benchmarks. Resources: ruler, compass, protractor Expertise: 1		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
Regression Analysis	George M, Rowlands D, Price M, et al. Identifying and verifying causes. The lean six sigma pocket toolbook. New York: McGraw–Hill; 2005. p. 141-96. Tague N. The tools. In: O'Mara P, editor. The quality toolbox. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2005. p. 93-521.	Regression analysis is used in conjunction with correlation calculations and scatter plots to predict future performance based on past results. Regression defines the relationship more precisely than correlation coefficients alone. Regression analysis is a tool that uses data on relevant variables to develop a prediction equation, or model [Y = f(x)]. Regression analysis is a statistical tool used to find a model for a relationship between pairs of numerical data. The model is a line or curve that fits the data best. The results of a regression analysis are an equation for that line or curve, a value called r^2 that indicates how good the fit is, and other statistical measures that tell how well the data match the model. Used: • To predict future performance based on past results • When you have paired numerical data • After drawing a scatter diagram of the data • When you want to know how a change in the independent variable affects the dependent variable	1. Plan data collection. What inputs or potential causes will you study? What output variable(s) are key? How can you get data? How much data do you need? 2. Perform analysis and eliminate unimportant variables. Collect the data and generate a regression equation. Which input variables have the biggest effect on the response variable? What factor or combination of factors are the best predictors of output? 3. Select and refine model. Delete unimportant factors from the model. 4. Validate model. Collect new data to see how well the model is able to predict actual performance. While linear regression can be done manually, computer software makes the calculations easier. Follow the instructions accompanying your software. The analysis will generate a graph of the best-fit regression line placed through the data and a table of statistics. These will include:		

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		• When you want to be able to predict the dependent variable if you know the independent variable • When you want a statistical measure of how well a line or curve fits the data	*Slope* of the line. The equation for the line has the form y = mx + b. The slope is the constant m. This tells us that when the independent (x) variable increases by one, the dependent variable (y) will increase by m. Positive slope means the line slants upward from left to right; negative slope means the line slants downward. *Intercept* of the line. In the line's equation, the intercept is the constant b. This is the value of y where the line crosses the y-axis. Knowing the slope and intercept, you can draw the line or predict y from a given value of x: y = mx + b. *Coefficient of determination*, r^2. This number, which is between 0 and 1, measure how well the data fits the line. If r^2 = 1, the line fits the data perfectly. As r^2 gets smaller, the line's fit becomes poorer, and predictions made from it will be less accurate. You can think of r^2 as the proportion of y's variation that is explained by the regression line. Because most data		

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			points don’t fall exactly on the line, the rest of the proportion ($1—r^2$) is error. *Confidence interval*, often 95%. This is a range of values around one or more of the previous statistics. One can be 95% sure that the true value of that statistic lies within the range. A 95% confidence interval for the line is the space in which you can be 95% sure the true regression line will lie. The results will include additional values. Consult the software’s user guide or help function, a statistics book, or a statistician to learn more about them Resources: statistical software, paired numerical data Expertise: 3		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
Relations Diagram (Also called: interrelationship diagram or digraph, network diagram, activity network layout)	American Society for Quality. Seven new management and planning tools: Relations diagram. 2009. Available at: http://www.asq.org/learn-about-quality/new-management-planning-tools/overview/relations-diagram.html. Accessed July 23, 2009. Lighter D. Process orientation in health care quality. In: Moore C, editor. Quality management in health care: principles and methods. 2 ed. Sudbury, MA: Jones and Bartlett Publishers; 2004. p. 43-101. Tague N. The tools. In: O'Mara P, editor. The quality toolbox. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2005. p. 93-521. Bauer J, Duffy G, Westcott R, editors. The quality improvement handbook, Improvement tools. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2006. p. 109-48. Andersen B. Tools for analyzing the performance shortcoming. In: O'Mara	A relations diagram is a tool to identify logical cause-and-effect relationships in a complex and confusing problem or situation. For problems or situations where there is a network of such relationships, a relations diagram is particularly useful, as it has the ability to visualize them. Just as importantly, the process of creating a relations diagram helps a group analyze the natural links between different aspects of a complex situation. The relations diagram shows cause-and-effect relationships. Just as importantly, the process of creating a relations diagram helps a group analyze the natural links between different aspects of a complex situation. Indicates cause-and-effect relationships that may be affecting the efficiency of the process It defines interactions between variables or concepts that can lead to improvement in the process. The relations diagramming method is a technique developed to clarify intertwined causal relationships in a complex situation in order to find an	1. WRITE A STATEMENT DEFINING THE ISSUE that the relations diagram will explore. Write on card and place on work surface. 2. BRAINSTORM IDEAS about the issue and write them on cards or notes. If another tool has preceded this one (affinity diagram, tree diagram, etc.), use those ideas as starting points. 3. Place one idea at a time on the work surface and ASK: "Is this idea related to any others?" Place ideas that are related close to each other. 4. For each idea, ASK, "Does this idea cause or influence any other idea?" Draw arrow from each idea to the ones it causes or influences. 5. ANALYZE THE DIAGRAM. a. Count arrows in and out for each idea. The ones with the most are the key ideas. b. Note which ideas have primarily outgoing arrows. These are basic causes. c. Note which ideas have primarily	Pros: • Can be completed quickly Cons: • Will not work well if list of ideas is too long (more than 50)	

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
	P, editor. Business process improvement toolkit. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2007. p. 123-55.	appropriate solution. A relations diagram is a tool to identify logical cause-and-effect relationships in a complex and confusing problem or situation. For problems or situations where there is a network of such relationships, a relations diagram is particularly useful, as it has the ability to visualize them. There are two type of relations diagrams: qualitative and quantitative. In the qualitative diagram, both the problem and causes at several levels can be included. The diagram is actually quite similar to the traditional cause-and-effect chart, but it is more suited for complex problems. Used: • When trying to understand links between ideas or cause-and-effect relationships • When a complex issue is being analyzed for causes • When a complex solution is being implemented • After generating an affinity diagram, cause-and-effect diagram or tree diagram, to more completely explore the relations of ideas • To establish which inputs and outputs will require monitoring to optimize efficiency	incoming arrows. These are final effects that may be critical to address. 1. List all possible concepts and issues for a project; if the list is too long, then combine some concepts or divide the list into subprojects or related ideas. 2. Place the components on sticky notes or note cards and connect the cards that are related. Some computer programs (e.g. Visio) can simplify the process by automating this step. 3. Work with the quality improvement team and those responsible for implementing the project to refine the relationships between the concepts and issues. Qualitative procedure: 1. Isolate all factors believed to be related to the problem. Without forming an opinion about the relationships between the factors, each of these is freely expressed on an individual basis. Boxes can very well be drawn that contain the factors.		

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		• To determine and develop quality assurance policies • To establish promotional plans for total quality control introduction • To design steps to counter market complaints • To promote quality control in purchased or ordered items • To provide measures against troubles related to payment and process control • To promote small group activities effectively • To reform administrative and business departments	2. Identify the causal relationships between the factors and illustrate these with the help of arrows in the diagram. 3. Classify the factors depending on which role they play in the cause-and-effect situation. 4. Concentrate the improvement effort around the main causes of the problem. Quantitative procedure: 1. Place the factors to be included in the analysis throughout the diagram, preferably in a coarse circular shape. 2. For each factor, assess which other factors this impacts or is impacted by, and indicate these impacts with arrows. The direction of the arrow indicates the direction of the impact—that is, an arrow pointing to factor B from factor A means that factor A impacts factor B. 3. After all relationships have been assessed, the number of arrows is counted and denoted in the diagram. Resources: note cards Expertise: 1		

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Requirements Table	Tague N. The tools. In: O'Mara P, editor. The quality toolbox. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2005. p. 93-521.	The requirements table is a format for identifying customers and their requirements. It separates customers into four different categories and requirements into two categories. Thinking about the categories leads to a more complete list of customers and requirements. Used: • When developing or working with a list of customers • When developing or working with a list of customers' requirements	1. DEFINE THE PRODUCT OR SERVICE. Write it at the top of the form. 2. BRAINSTORM A LIST OF CUSTOMERS. Ask, "Who cares about the quality of what we do or how we do it?" Use these four categories to help develop a complete list: *External customer*. A purchaser or end user of the product or service, or that person's representative, who is outside your company or organization. *Internal customer*. A user of the product or service who belongs to your own company or organization. *Society*. Society has an interest in certain aspects of products, services, and how processes are run. Society's interests usually are represented by agencies such as the EPA, OSHA, certification boards, and so forth. Members of communities in which offices or facilities are located also have interest in aspects of their operation. *Supplier*. Suppliers may have interests in how materials are used or presented or in when or how information is communicated. 3. For each customer,		

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Requirements and Measures Tree	Tague N. The tools. In: O'Mara P, editor. The quality toolbox. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2005. p. 93-521. Lighter D. Process orientation in health care quality. In: Moore C, editor. Quality management in health care: principles and methods. 2 ed. Sudbury, MA: Jones and Bartlett Publishers; 2004. p. 43-101.	The requirements-and-measures tree organizes customers, their requirements, and related measurements for a product or service. The relationships between all the customers, requirements, and measures become visible. Relates the elements of a product or service that customers value to the process. Used: • When developing requirements or measures • To organize a complex set of requirements and/or measures • To visually describe a set of requirements, measures, and their relationships for a process • In planning for a process • To ensure that customer needs are being met as the process is designed or redesigned • To provide a visual representation of process relationships	1. IDENTIFY ONE PROCESS OUTPUT. Write it on a sticky note and place at the top of a flipchart page. 2. IDENTIFY ALL CUSTOMERS of that output. Write each one on a sticky note and place on the page under the output. 3. For each customer, IDENTIFY ALL REQUIREMENTS. Be as specific as possible, using operational definitions. For example, don't say "timely." Instead say, "received by Friday noon." Write each requirement on a note and place it under the customer's name. 4. At this point, some requirements may be duplicated, or natural groupings may be obvious. REORGANIZE THE REQUIREMENTS if desired. Draw lines to show connections between customers and requirements. 5. For each requirement, BRAINSTORM POTENTIAL MEASUREMENTS. Follow good brainstorming techniques and try uncritically to generate as many as possible.	Pros: • Provides a quick overview of customer requirements and the methods used to measure the requirements • Reveals relationships between measures that can reduce the chance that a particular output may escape measurement • Ensures that all pertinent customers will evaluate a particular output	

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			Then discuss and evaluate the measures. Reduce the list to a manageable number. 1. SELECT A PRODUCT OR SERVICE OUTPUT from the process. 2. DEFINE ALL POTENTIAL INTERNAL AND EXTERNAL CUSTOMERS for the product or service. 3. LIST ALL REQUIREMENTS for each of the customers. Look for duplication or overlap in requirements so that the list may be consolidated. 4. DETERMINE MEASURES for each of the requirements, but spare the list to a reasonable number. 5. DEFINE THE MEASURES in terms of data required to produce the measure, who will be responsible for producing the measure, and how it will be distributed. Resources: sticky notes, flip chart Expertise: 1		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
Root Cause Analysis	Lighter D. Process orientation in health care quality. In: Moore C, editor. Quality management in health care: principles and methods. 2 ed. Sudbury, MA: Jones and Bartlett Publishers; 2004. p. 43-101. Kazandjian V. Root cause analysis and disclosure. In: O'Mara P, editor. Accountability Through Measurement: A Global Healthcare Imperative. Milwaukee, WI: ASQ Quality Press; 2003. p. 99-109. Mind Tools Ltd. Root cause analysis. 2009. Available at: http://www.mindtools.com/pages/article/newTMC_80.htm. Accessed August 24, 2009.	Analyzes the situation in which an error has occurred to determine the underlying cause(s) of the error and make recommendations for preventing the error in the future. RCA involves the applications of several tools. Root Cause Analysis (RCA) is a popular and often-used technique that helps people answer the question of why the problem occurred in the first place. Root Cause Analysis seeks to identify the origin of a problem. It uses a specific set of steps, with associated tools, to find the primary cause of the problem, so that you can: 1. Determine what happened. 2. Determine why it happened. 3. Figure out what to do to reduce the likelihood that it will happen again. RCA assumes that systems and events are interrelated. An action in one area triggers an action in another, and another, and so on. By tracing back these actions, you can discover where the problem started and how it grew into the symptom you're now facing. Used: • To find the cause of an error	1. ASSEMBLE A TEAM OF PROCESS EXPERTS to evaluate the event. 2. CREATE A PROCESS FLOW DIAGRAM if one does not already exist. 3. EXAMINE THE FLOWCHART for the procedure that failed and led to a suboptimal outcome. 4. USE SPECIALIZED FLOWCHARTS (e.g., PERT diagram, deployment flowchart). 5. USE GROUP TECHNIQUES (brainstorming, brainwriting, nominal group technique) to refine and prioritize underlying root causes of the faulty procedure. 6. USE QUALITY IMPROVEMENT TOOLS such as the Ishikawa diagram, relationship diagrams, and tree diagrams to help relate data to specific root causes. 7. REDESIGN THE PROCESS using group techniques and list reduction techniques (e.g., multivoting) to optimize the group's decisions. 8. IMPLEMENT THE CHANGES in a pilot project, if possible, prior	Pros: • Culminates in the identification of underlying causes of problems in process	Modaro C, Oyola T. Improvement of specimen courier system. 17th Annual Society for Health Systems Management Engineering Forum; 2005; Dallas, TX; 2005. Latino RJ. Case studies. Patient safety: the PROACT® root cause analysis approach. Boca Raton, FL: CRC Press; 2009. p. 171-87. Latino RJ. The "5 PS" concept. Patient safety: the PROACT® root cause analysis approach. Boca Raton, FL: CRC Press; 2009. p. 77-86.

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			to generalizing the change to all areas of the organization. * RCA template available in MindTools Resources: none Expertise: 1		

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Scatter Diagram (Also called: scatter plot, X-Y graph)	American Society for Quality. Cause analysis tools: Scatter diagram. 2009. Available at: http://www.asq.org/learn-about-quality/cause-analysis-tools/overview/scatter.html. Accessed 2009 July 23, 2009. University Research Co. LLC. Quality Assurance Project: Scatter diagram. 2008. Available at: http://www.qaproject.org/methods/resscatter.html. Accessed July 28, 2009. George M, Rowlands D, Price M, et al. Identifying and verifying causes. The lean six sigma pocket toolbook. New York: McGraw–Hill; 2005. p. 141-96. Tague N. The tools. In: O'Mara P, editor. The quality toolbox. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2005. p. 93-521. Bauer J, Duffy G, Westcott R, editors. The quality improvement handbook, Improvement Tools. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2006. p. 109-48.	Graphs pairs of numerical data, with one variable on each axis, to look for a relationship between them. If the variables are correlated, the points will fall along a line or curve. The better the correlation, the tighter the points will hug the line. A scatter diagram shows the association between two variables acting continuously on the same item. It illustrates the strength of the *correlation* between the variables through the slope of a line. This correlation can point to, but does not prove, a *causal* relationship. A scatter diagram is a chart in which one variable is plotted against another to determine whether there is a correlation between the two variables. These diagrams are used to plot the distribution of information in two dimensions. Scatter diagrams are useful in rapidly screening for a relationship between two variables. A scatter diagram shows the pattern of relationship between two variables that are thought to be related. A scatter chart can be used to show the relationship between two variables. The variables can be process	1. Collect pairs of data where a relationship is suspected. 2. Draw a graph with independent variable on the horiz. Axis and dependent variable on vert. axis. Plot pairs of data points. 3. Look at the pattern of points to see if a relationship is obvious (line or curve). If there is, may wish to perform regression or correlation analysis. 4. Divide points on graph into 4 quadrants. If there are X points on the graph: a. Count X/2 points from top to bottom and draw horiz. line b. Count X/2 points from left to right and draw a vert. line c. If number of points is odd, draw line through middle point 5. Count points in each quadrant. 6. Add diagonally opposite quadrants. Find smaller sum and total of points in all quadrants. • A=points in upper left + points in lower right • B=points in upper right + points in lower	Pros: • Scatter diagram is first step in looking for a relationship between two variables • The simplest way to determine if a cause-and-effect relationship exists between two variables • Lets you see patterns in data • Helps support or refute theories about the data • Helps create or refine hypotheses • Predicts effects under other circumstances • Easily done with spreadsheet software Cons: • Pattern doesn't necessarily mean there's a relationship. Could be influenced by a third variable. • Results can be skewed if data doesn't cover a wide enough range • Stratifying the data in different ways can make patterns appear or disappear • Interpretation can be limited by the scale used • Sometimes the correlation observed is due to some cause other than the one being studied • Do not prove that one variable causes the other	

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	Andersen B. Tools for analyzing the performance shortcoming. In: O'Mara P, editor. Business process improvement toolkit. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2007. p. 123-55. The Boeing Company. Advanced quality system tools. 1998. Available at: http://www.boeing.com/companyoffices/doingbiz/supplier/d1-9000-1.pdf. Accessed August 24, 2009.	characteristics, performance measures, or other conditions and are usually measured at specified time intervals. When one of the factors increases, the other can also decrease, or display only random variation. If the two variables seem to change in synchronization, it might mean that they are related and impact each other. A plot of one measured variable against another. Paired measurements are taken on each item and plotted on a standard X-Y graph. Used: • When have paired numerical data • When dependent variable may have multiple vales for each value of your independent variable • When trying to determine whether two variables are related • To make the relationship between two continuous variables stand out visually on the page in a way that the raw data cannot • To show relationships between two effects to see if they might stem from a common cause or serve as surrogates for each other • To display what happens to one variable when another	left • Q=the smaller of A and B • N=A + B 7. Look up limit for N on trend test table a. If Q is less than limit, two variables are related. b. If Q is greater than or equal to limit, patter could be random *Scatter diagram template in ASQ 1. Collect at least 40 paired data points: "paired" data are measures of both the cause being tested and its supposed effect at one point in time. 2. Draw a grid, with the "cause" on the horizontal axis and the "effect" on the vertical axis. 3. Determine the lowest and highest value of each variable and mark the axes accordingly. 4. Plot the paired points on the diagram. If there are multiple pairs with the same value, draw as many circles around the point as there are additional pairs with those same values. 5. Identify and classify the pattern of association using the		

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		variable is changed • When there is a need to display what happens to one variable when another one changes • When confirming relationships identified in a cause and effect diagram	graphs below of possible shapes and interpretations. 1. Collect paired data. 2. Determine appropriate measures and increments for the axes on the plot. Mark units for the suspected cause (input) on the horizontal x-axis. Mark the units for the output (Y) on the vertical y-axis. 3. Plot the points on the chart. 1. DEFINE THE X VARIABLE on a graph paper scatter diagram form. This variable is often thought of as the cause variable and is typically plotted on the horizontal axis. 2. DEFINE THE Y VARIABLE on the diagram. This variable is often thought of as the effect variable and is typically plotted on the vertical axis. 3. NUMBER THE PAIRS OF X AND Y VARIABLE MEASUREMENTS CONSECUTIVELY. Record each pair of measures for x and y in the appropriate columns. Make sure that the x measures and the		

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			corresponding y measures remain paired so that the data are accurate. 4. PLOT THE X AND Y DATA PAIRS on the diagram. Locate the x value on the horizontal axis, and then locate the y value on the vertical axis. Place a point on the graph where these two intersect. 5. STUDY THE SHAPE that is formed by the series of data points plotted. In general, conclusions can be made about the association between two variables (referred to as x and y) based on the shape of the scatter diagram. Scatter diagrams that display associations between two variables tend to look like elliptical spheres or even straight lines. 6. Scatter diagrams on which the plotted points appear in a circular fashion show little or no correlation between x and y. 7. Scatter diagrams on which the points form a pattern of increasing values for both variables show a positive correlation; as values of x increase, so do values		

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			of y. The more tightly the points are clustered in a linear fashion, the stronger the positive correlation, or the association between the two variables. 8. Scatter diagrams on which one variable increases in value while the second variable decreases in value show a negative correlation between x and y. Again, the more tightly the points are clustered in a linear fashion, the stronger the association between the two variables. 1. Select the two variables, one independent and one dependent, to be examined. 2. For each value of the independent variable, the corresponding value of the dependent variable is measured. These two values form a data pair to be plotted in the chart. Typically, there should be at least 30, but preferably more than 100, data pairs to produce a meaningful chart. 3. Draw the char t by placing the independent variable, that is, the expected cause		

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			variable, on the x axis, and the dependent, the expected effect variable, on the y axis. 4. Plot the collected data pairs on the chart and analyze them. If the chart shows no correlation, the data pairs can be drawn in a logarithmic chart. Such a chart can reveal connections that are not visible in a chart with ordinary axes. 1. Collect twenty or more paired samples of data believed to be related. 2. Construct a data sheet. 3. Draw the horizontal and vertical axes of the scatter diagram. The values marked on the axis should get larger as you move up or to the right on each axis. 4. Label the axes. The variable that is being investigated as the possible "cause" is on the horizontal axis, and the "effect" variable is on the vertical axis. 5. Plot the paired data on the diagram. Resources: Paired data, spreadsheet software Expertise: 2		

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Simulation (Also called: Role Playing, Scenario-based Evaluation)	Center for Quality and Productivity Improvement. CPOE usability resources. 2010. Available at: http://cqpi.engr.wisc.edu/cpoe_usability. Accessed May 25, 2010.	A form of usability evaluation in which realistic cases are created and the participant is provided direction (of varying degree) on use of the system. Used: • During the design phase of the system to assess specific functions or design features • When developing a training program on how to use the system	1. Determine system design/features to evaluate 2. Once the system is sufficiently designed and programmed, **create simulated patient/case** with sufficient data in fields affecting function/design being evaluated 3. **Develop script** directing user what they are to accomplish (can be prescriptive—step-by-step, or general –ask user to complete a specific task with no direction/instruction) 4. **Observe user** while they are performing tasks assigned; take notes 5. **Debrief user** upon completion of simulation; take notes 6. **Evaluate results** of evaluation and determine how to address results (e.g., system redesign; training, workflow modification) Resources: Data collection instruments Expertise: 2	Pros: • Involves user in providing feedback on system design • Feedback is provided on proposed design Cons: • Development of detailed script may be time-consuming • Avoid raising unrealistic expectations by participant-user	

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Simulation Modeling	Avni T. Value stream mapping and simulation modeling: An integrated approach to workflow analysis in health care. 2007. Available at: http://www.nahq.org/journal/online/septoct2007.pdf. Accessed June 24, 2009. Lowery J. Getting started in simulation in health care. 1998 Winter Simulation Conference Proceedings; 1998; San Diego, CA; 1998. Perez-Velez R. Improving CT scan throughput using process improvement, analysis and simulation methodologies. 17th Annual Society for Health Systems Management Engineering Forum 2005; Dallas, TX; 2005. Dronzek R. Healthcare simulation modeling. 2007 Society for Health Systems Conference; 2007; New Orleans, LA; 2007. Slonim A. Improving health care quality in the pediatric ambulatory OR setting. 2007 Society for Health Systems Conference; 2007; New Orleans, LA; 2007.	A dynamic mathematical tool, mimicking the behavior of a process over time. Simulation modeling captures the complex interdependencies of time-based events and resources influenced by random sources of variation. Enables the modeling of complex systems with lots of interacting parts and uncertainty, two major characteristics in health care. Simulation is the imitation of the operation of a real-world process or system over time. Creating a computerized model of a system that takes into account changes over time and process variation Simulation is a powerful tool that uses computerized models of health care systems to make design decisions and performance enhancements. It has as its output, clinical, business and service performance targets, linked through *processes*, using a shared *information* platform. Used: • To define requirements • To test a process or workflow without actually	Banks and Carson (1995) describe the steps in a simulation study. They include: (1) problem formulation; (2) setting of objectives and overall project plan; (3) model building; (4) data collection; (5) coding; (6) verification; (7) validation; (8) experimental design; (9) production runs and analysis; (10) repeat of step (9) if necessary; (11) documentation of program and reporting of results; and (12) implementation of proposed system. (Steps *3* and 4 take place concurrently.) 1. WALKTHROUGH OF ENTIRE PROCESS 2. MAPPING OF MICROSYSTEM LEVEL processes and their relationship to Macrosystem 3. OBTAINING REAL TIME OR HISTORICAL DATA from time studies, business and clinical systems 4. DATA DISTRIBUTIONS, with their descriptive statistical elements need to be collected 5. SELECT APPROPRIATE MODELING	Pros: • Useful for modeling uncertainty • Simulation is usually cheaper than testing the actual process • Simulation can be made to almost any desired level of detail • Quickly runs months and years of operations • Captures interdependencies while reducing complexity • Models each entity moving through a system • Effective method of analysis • Ability to analyze impact of potential process changes prior to their implementation • Account for variability in system • Provides data on multiple performance measures • Quantitative analysis of current state and recommended changes • Instant "on the fly" testing of scenarios to examine optimal staffing patterns, new processes and volume changes • Useful in investigating the effect of changes in various parameters of a system Cons: • Simulation software can be expensive and complicated • If inputs are bad, output will be bad • It is only simulation • Time consuming	Bhagat A, Wang S, Khasawneh MT, et al. Enhancing hospital health information management using industrial engineering tools. 2008. Available at: http://www.iienet2.org/uploadedFiles/SHS_Community/Enhancing Hospital Health Information Management using Industrial Engineering Tools.pdf. Accessed May 20, 2009. Jurishica C. Simulation medication: Studies show patient flow improvement. 2007 Society for Health Systems Conference; 2007; New Orleans, LA; 2007. Modaro C, Oyola T. Improvement of specimen courier system. 17th Annual Society for Health Systems Management Engineering Forum; 2005; Dallas, TX; 2005. Yanko S, Gomez E. Tools, techniques, and best practices in the emergency room 2007 Society for Health Systems Conference; 2007; New Orleans, LA; 2007. Lin L, Paul J. Simulation and lean six-sigma

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	Kachhal S. Industrial engineering applications in health care systems. In: Salvendy G, editor. Handbook of industrial engineering: technology and operations management. 3rd ed. New York: John Wiley & Sons, Inc.; 2001. p. 737-50. Laughery Jr. K, Archer S, Corker K. Modeling human performance in complex systems In: Salvendy G, editor. Handbook of industrial engineering: technology and operations management. 3rd ed. New York: John Wiley & Sons, Inc.; 2001. p. 2409-44. Lepley C. Simulation software: Engineer processes before reengineering. J Nurs Adm 2001 Jul-Aug;31(7-8):377-85.	performing it • In conceptual & detailed design • In operations • In sales and marketing • In training	SOFTWARE 6. BUILDING MODEL using process flows, actual floor plans and various performance measures 7. VALIDATION: This requires that composite data and process pieces be verified by team including front line staff 8. DEVELOP BASELINE MODEL 9. RUN MULTIPLE 'WHAT-IF' SCENARIOS to generate data 10. MAKE OPERATIONAL DECISION to implement changes to improve process Problem formulation, setting of objectives and overall project plan, model building, data collection, coding, verification, validation, experimental design, production run and analysis, additional runs, document program and report results, implementation Resources: simulation software Expertise: 3	• Requires unique skill set (consulting, experimental design, information systems) • Validation may be difficult	integration for improvement of hospital operations. 2007 Society for Health Systems Conference; 2007; New Orleans, LA; 2007. Clancy T, Delaney C, Segre A, et al. Predicting the impact of an electronic health record on practice patterns using computational modeling and simulation. AMIA 2007 Symposium Proceedings; 2007: AMIA; 2007. p. 145. Ledlow G, Bradshaw D. Animated simulation: A valuable decision support tool for practice improvement. J Healthc Manag 1999 Mar-Apr;44(2):91-101; discussion -2.

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SIPOC (Supplier, Inputs, Process, Outputs, Customer)	George M, Rowlands D, Price M, et al. Value stream mapping and process flow tools. The lean six sigma pocket toolbook. New York: McGraw–Hill; 2005. p. 33-54. Tague N. The tools. In: O'Mara P, editor. The quality toolbox. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2005. p. 93-521.	A process snapshot that captures information critical to a project. SIPOC diagrams help a team and its sponsor(s) agree on project boundaries and scope. SIPOC helps teams verify that process inputs match outputs of the upstream process and inputs/expectations of downstream process (es). SIPOC stands for *suppliers-inputs-process-outputs-customers*. A SIPOC diagram shows a high-level flowchart of a process and lists all suppliers, inputs, outputs, and customers. A SIPOC diagram provides a quick, broad view of key elements of a process. Used: • At the beginning of a project, to help define the important elements of the project • When it is not clear what the process inputs are, who supplies them, what the outputs are, or who the customers are • When there are many suppliers, inputs, outputs, and/or customers	1. Identify process boundaries and key activities. Keep at a high level, 6 activities or so at most. 2. Identify the key outputs (Ys) and customers of those outputs. 3. Identify inputs (Xs) and suppliers. 4. Identify critical-to-quality requirements for the inputs, process steps, and outputs. 1. GATHER A GROUP OF PEOPLE who are knowledgeable about the process. Identify the process under study. 2. CREATE A MACRO OR TOP-DOWN FLOWCHART OF THE PROCESS. Display it where everyone can see it throughout the rest of the procedure. Be sure to include starting and ending points for the process. 3. IDENTIFY THE OUTPUTS of the process. Record all of them on a flipchart, on sticky notes attached to a wall, or on a transparency. Regardless of where they are recorded, have a heading reading “Outputs.” 4. IDENTIFY THE	Pros: Helps define the scope of a project	

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			CUSTOMERS who receive the outputs. Record them on a separate flipchart, wall area, or transparency, with the heading "Customers." 5. IDENTIFY THE INPUTS that the process needs. Record them separately as before. 6. IDENTIFY THE INPUTS' SUPPLIERS. Once more, record them separately. 7. REVIEW ALL YOUR WORK to find omissions, duplications, unclear phrases, inaccuracies, and so on. 8. DRAW A COMPLETE SIPOC DIAGRAM. Resources: sticky notes, flip chart Expertise: 1		

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Six Sigma	Lucansky P, Burke R. Lean six sigma in the office. The tools and techniques to streamlining your office processes. 17th Annual Society for Health Systems Management Engineering Forum; 2005; Dallas, TX; 2005. Johnson C, Allen R, Wedgewood I. Attacking waste and variation hospital-wide: A comprehensive lean-sigma deployment. 2007 Society for Health Systems Conference; 2007; New Orleans, LA; 2007. McCray M. How to get paid for the services you provide. 2007 Society for Health Systems Conference; 2007; New Orleans, LA; 2007. Quetsch J. Patient safety with six sigma, lean, or theory of constraints. 2007 Society for Health Systems Conference; 2007; New Orleans, LA; 2007. Tague N. Mega-tools: Quality management systems. In: O'Mara P, editor. The quality toolbox. 2nd ed. Milwaukee, WI: ASQ	Promotes excellence in all business processes—improve productivity, profits, and customer satisfaction. A process which produces less than 3.4 defects per million opportunities (DPMO). A tool to reduce or eliminate variation. A systematic methodology to focus on the key factors that drive the performance of a process, set them at the best levels, and hold them there for all time. Six Sigma is an organization-wide approach used to achieve breakthrough improvements tied to significant bottom-line results. Unlike previous total quality management approaches, Six Sigma specifies exactly how the organization's managers should set up and lead the effort. Key features are the use of data and statistical analysis, highly trained project leaders known as Black Belts and Green Belts, project selection based on estimated bottom-line results, and the dramatic goal of reducing errors to about three per million opportunities.	DMAIC: 1. DEFINE the project 2. MEASURE the current situation 3. ANALYZE to identify causes 4. IMPROVE develop, test, implement solutions and evaluate results using data 5. CONTROL maintain the gains Resources: none Expertise: 3	Pros: • Improved products and services Cons: • Investment in Six Sigma is moderate to high • Books are limited in scope and tend to be technical	Roberts L, Johnson C, Shanmugam R, et al. Computer simulation and six-sigma tools applied to process improvement in an emergency department. 17th Annual Society for Health Systems Management Engineering Forum 2005; Dallas, TX; 2005. Holst T. Improving first-case OR start times by utilizing six sigma methodologies. 2007 Society for Health Systems Conference; 2007; New Orleans, LA; 2007. Latino RJ. Six sigma and PROACT RCA. Patient safety: the PROACT® root cause analysis approach. Boca Raton, FL: CRC Press; 2009. p. 66-70. Bisgaard S. Solutions to the healthcare quality crisis: cases and examples of lean six sigma in healthcare. Milwaukee, WI: ASQ Quality Press; 2009.

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	Quality Press; 2005. p. 13-34. Zidel T. Six sigma. In: O'Mara P, editor. a lean guide to transforming healthcare. Milwaukee, WI: ASQ Quality Press; 2006. p. 107-14. Shankar R. Process improvement using six sigma. Milwaukee, WI: ASQ Quality Press; 2009. Andersen B. Tools for creating improvements. In: O'Mara P, editor. Business process improvement toolbox. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2007. p. 167-236. Barry R. The manager's guide to six sigma in healthcare: practical tips and tools for improvement. Milwaukee, WI: ASQ Quality Press; 2005.				

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SMART Matrix	American Society for Quality. SMART matrix. 2009. Available at: http://www.asq.org/healthcare-use/why-quality/smart-matrix.html. Accessed August 31, 2009.	A SMART matrix is a communication and planning tool used to identify the specifics of actions or tasks. SMART stands for *specific, measurable, attainable, resources,* and *time*. It is an L-shaped matrix designed to capture the key points of a team's project objectives. The SMART matrix provides a process to review how actions are being implemented around various attributes. Used: • When you need to analyze an implementation plan's tasks to ensure they are on track • When you need to understand the amount of resources needed to implement a plan • When you need to understand how the various tasks are sequenced and related	1. On a piece of flip chart paper DRAW AN L-SHAPED MATRIX with five columns labeled Specific, Measurable, Attainable, Resources, and Time. 2. WRITE THE IMPLEMENTATION PLAN TITLE in the upper left of the chart. 3. DETAIL THE SPECIFIC TASKS TO BE PERFORMED. Make the task statement detailed and well defined. 4. For each detailed specific task: Define a measure or indicator that can be tracked Determine how it will be attained in actionable terms that are realistic and feasible Indicate the amount and type of resources required to complete each task identified Identify the timeline for completion 5. Once you have completed the matrix, REVIEW THE RESULTS with the implementation team to ensure that you have accounted for and recorded everything 6. REVIEW THE MATRIX to make sure the timeline is realistic		

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			and all tasks are not due to be completed on the same day. 7. REVIEW THE MATRIX and get a feel for the total amount of resources required. Determine if they are available or if adjustments need to be made. Resources: none Expertise: 1		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
Social Network Analysis (SNA)	Stanton N, Salmon P, Walker G, et al. Team assessment methods. Human factors methods: a practical guide for engineering and design. Great Britain: Ashgate; 2005. p. 365-429.	Social Network Analysis (SNA) is used to analyze and represent the relationships between groups of agents or teams. A social network is defined as a 'set or team of agents that possess relationships with one another'. SNA can be used to demonstrate the type, importance and the number of relationships within a specified group. The output typically provides a graphical depiction and a mathematical analysis of the relationships exhibited within the group under analysis. Depending upon the focus of the analysis, a number of facets associated with the network can be analyzed, such as centrality, closeness and betweenness, all of which provide an indication of agent importance within the network in terms of communications. A network density figure can also be derived, which gives an indication of how well the network of agents is distributed. Used: • To demonstrate the type, importance and the number of relationships within a specified group • To identify the frequency and direction of communications within a network	1. DEFINE NETWORK OR GROUP. The first step in a SNA involves defining the network of agents or group of networks that are to be analyzed. 2. DEFINE SCENARIOS. Typically, networks are analyzed over a number of different scenarios. Once the type of network under analysis has been defined, the scenario(s) within which they will be analyzed should be defined. For a thorough analysis of the networks involved, it is recommended that a number of different scenarios be analyzed. 3. DATA COLLECTION. Once the network and scenario(s) under analysis are defined clearly, the data collection phase can begin. The data collection phase typically involves conducting an observational study of the scenario(s) under analysis. It is recommended that specific data regarding the relationship (e.g. communications) between the agents involved in the scenario is collected. Typically	Pros: • SNA can be used to determine the importance of different agents within a team or group of agents • The SNA offers a comprehensive analysis of the network in question. The key agents within the network are identified, as are the frequency and direction of communications within the network. Further classifications include network type and network density. There are also additional analyses that can be calculated, such as betweenness, closeness, and distance calculations. • Networks can be classified according to their structure. This is particularly useful when analyzing networks across different domains. • The method has been used extensively in the past for the analysis of various social networks • The method is simple to learn and easy to use • The Agna SNA software package reduces application time considerably • SNA is a generic method that could potentially be applied in any domain involving team-based or collaborative activity Cons: • For large, complex networks, it may be difficult to conduct a SNA. Application time is a	

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			the frequency, direction and content of any communications between agents in the network are recorded. Additional data collection techniques may also be employed in order to gather supplementary data, such as interviews and questionnaires. 4. Once sufficient data regarding the scenario under analysis is collected, the data analysis component of the SNA can begin. The first step in this process involves the CONSTRUCTION OF AN AGENT ASSOCIATION MATRIX. The matrix represents the frequency of associations between each agent within the network. 5. CONSTRUCT SOCIAL NETWORK DIAGRAM. Once the matrix of association is completed, the social network diagram should be constructed. The social network depicts each agent in the network and the communications that occurred between them during the scenario under analysis. Within	function of network size, and large networks may incur lengthy application times. • The data collection phase involved in a typical SNA is resource intensive • Some knowledge of mathematical methods is required • It is difficult to collect comprehensive data for a SNA. For example, a dispersed network of ten agents would require at least 10 observers in order to accurately and comprehensively capture the communications made between all agents. • Without the provision of a (Agna) SNA software package, the method may be time consuming to apply	

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			the social network diagram, communications between agents are represented by directional arrows linking the agents involved, and the frequency of communications is presented in numeric form. 6. CALCULATE AGENT CENTRALITY. Agent centrality is calculated in order to determine the central or key agent(s) within the network. There are a number of different centrality calculations that can be made. For example, agent centrality can be calculated using Bavelas-Leavitt's index. The mean centrality + standard deviation can then be used to define key agents within the network. Those agents who possess a centrality figure that exceeds the mean + standard deviation figure a re defined as key agents for the scenario under analysis. 7. CALCULATE SOCIOMETRIC STATUS. The sociometric status of each agent refers to the number of		

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			communications received and emitted, relative to the number of nodes in the network. The mean sociometric status + standard deviation can also be used to define key agents within the network. Those agents who possess a sociometric status figure that exceeds the mean + standard deviation figure can be defined as key agents for the scenario under analysis. 8. CALCULATE NETWORK DENSITY. Network density is equal to the total number of links between agents in the network divided by the total number of possible links. Low network density figures are indicative of a well distributed network of agents. High density figures are indicative of a network that is not well distributed. Resources: SNA software Expertise: 2		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
Statistical Process Control (SPC)	American Society for Quality. Data collection and analysis tools: Control chart. 2009. Available at: http://www.asq.org/learn-about-quality/data-collection-analysis-tools/overview/control-chart.html. Accessed June 26, 2009. The Quality Assurance Project. Methods & tools: QA resources. 2009. Available at: http://www.qaproject.org/methods/resources.html. Accessed June 26, 2009. Loeb J, Schmaltz S, Hanold L, et al. Statistical tools for quality improvement. In: Ransom E, Joshi M, Nash D, Ransom S, editors. The Healthcare Quality Book: Vision, Strategy, and Tools. 2nd ed. Chicago: Health Administration Press; 2008. p. 131-67. Yeager K. Program evaluation: This is rocket science. In: Roberts A, Yeager K, editors. Evidence-based practice manual: research and outcome measures in health and human services. New York: Oxford University Press;	The control chart is a graph used to study how a process changes over time. Data are plotted in time order. A control chart always has a central line for the average, an upper line for the upper control limit and a lower line for the lower control limit. These lines are determined from historical data. By comparing current data to these lines, you can draw conclusions about whether the process variation is consistent (in control) or is unpredictable (out of control, affected by special causes of variation). They make trends or other non-random variation in the process easier to see and understand. With the understanding of patterns and trends of the past, groups can then use run charts to help predict future performance. The use of number and data to study the things we do in order to make them behave the way we want (McNeese and Klein 1991). In other words, SPC is a method of using data to track processes (the things we do) so that we can improve the quality of products and services (make them behave the way we want). SPC uses simple statistical tools to	1. Choose appropriate control chart for data 2. Determine appropriate time period for collecting and plotting data 3. Collect data, construct chart and analyze data 4. Look for "out-of-control signals" on the control chart. Mark ones identified and investigate cause. *Control chart template in ASQ 1. COLLECT AT LEAST 25 DATA POINTS (number, time, cost), recording when each measurement was taken. Arrange the data in chronological order. 2. DETERMINE THE SCALE for the vertical axis as 1.5 times the range. Label the axis with the scale and unit of measure. 3. DRAW THE HORIZONTAL AXIS and mark the measure of time (minute, hour, day, shift, week, month, year, etc.) and label the axis. 4. PLOT THE DATA POINTS. 5. INTERPRET THE RUN CHART: a. Eight consecutive	Pros: • Can clearly see points that are out of control, inconsistencies, and variation • Able to see trends in the data • Increased quality awareness on the part of health care organizations and practitioners • Increased focus on patients • Ability to base decision on data • Implementations of predictable health care processes • Cost reduction • Fewer errors and increased patients safety • Improved processes that result in improved health care outcomes and better quality care • Helps you understand your organization's capability of achieving targets • Easy to interpret using some basic guidelines • A provider of a given procedure can know if that procedure is within acceptable limits, and, if not, whether corrective actions should be taken Cons: Requires some understanding of statistics Value depends a lot on skill of the people using it	Taveras M. Increasing charge capture using scheduling techniques for a hospital-based ancillary service. 17th Annual Society for Health Systems Management Engineering Forum; 2005; Dallas, TX; 2005. McCray M. How to get paid for the services you provide. 2007 Society for Health Systems Conference; 2007; New Orleans, LA; 2007. Holst T. Improving first-case OR start times by utilizing six sigma methodologies. 2007 Society for Health Systems Conference; 2007; New Orleans, LA; 2007. Carey R. Improving healthcare with control charts: basic and advanced spc methods and case studies. Milwaukee, WI: ASQ Quality Press; 2003. Carey R, Lloyd R. Control chart case studies. Measuring quality improvement in healthcare: a guide to statistical process control applications. New York: Quality Resources; 1995. p. 79-149.

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	2004. p. 647-53. Hummel P, Gamble T. Reporting and analysis. In: Norris T, Fuller S, Goldberg H, et al., editors. Informatics in primary care. New York: Springer; 2002. p. 187-213. University Research Co. LLC. Quality Assurance Project: Run and control charts. 2008. Available at: http://www.qaproject.org/methods/resstattools2.html#run&controlcharts. Accessed July 28, 2009. Lighter D. Statistical process control: basic principles. In: Moore C, editor. Quality management in health care: principles and methods. 2nd ed. Sudbury, MA: Jones and Bartlett Publishers; 2004. p. 103-23. Fair D. Statistical process control approaches: basic theory and use of control charts. In: Moore C, editor. Quality management in health care: principles and methods. 2nd ed. Sudbury, MA: Jones and Bartlett Publishers; 2004. p. 127-71.	help us understand any process that generates products or services. Control charts are easy-to-use charts that make it easy to see both special and common cause variation in a process. Statistical control charts look at variation, seeking special causes and tracking common causes. A run chart provides a graphical display of data over time and is one of the tools used to display variation and to detect the presence or absence of special causes. Run charts give a picture of a variation in some process over time and help detect special (external) causes of that variation. They make trends or other non-random variation in the process easier to see and understand. With the understanding of patterns and trends of the past, groups can then use run charts to help predict future performance. Control charts are time-series analysis tools that track the consistency of data of calculated statistics through time. Control charts can be used for numerous applications in the health	points above or below center line suggest a shift in the process b. Six successive increasing or decreasing points suggest a trend c. Fourteen successive points alternating up and down suggest a cyclical process 1. Define the process to be evaluated. 2. Using a flowchart, outline each step in the process. 3. Evaluate the flowchart for potential quality problems or opportunities for improvement. 4. Determine potential interventions for the steps in the process that require improvement. 5. Define performance measures to monitor the progress of improvement. 6. Implement the intervention and observe the effects. 7. Evaluate the results and refine the intervention to continually improve the process. 1. Collect data and be sure to track the order in		

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	Besterfield D. Total quality management—Tools and techniques. In: Krassow E, editor. Quality control. 8th ed. Upper Saddle River, NJ: Pearson Prentice Hall; 2009. p. 77-115. George M, Rowlands D, Price M, et al. Variation analysis. The lean six sigma pocket toolbook. New York: McGraw–Hill; 2005. p. 117-40. Tague N. The tools. In: O'Mara P, editor. The quality toolbox. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2005. p. 93-521. Carey R, Lloyd R. Measuring quality improvment in healthcare: a guide to statistical process control applications. New York: Quality Resources; 1995. Andersen B. Tools for creating improvements. In: O'Mara P, editor. Business process improvement toolbox. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2007. p. 167-236. The Boeing Company. Advanced quality system	care industry in order to evaluate the quality of processes and monitor the results of quality improvement interventions. Run charts can also be used to evaluate trends in performance measures. They are relatively simple time plots of the median and the data, and runs are defined as groups of consecutive points above or below the median. A means of visualizing the variations that occur in the central tendency and dispersion of a set of observations. It is a graphical record of the quality of a particular characteristic. It shows whether or not the process is in a stable state. Used: • When controlling ongoing processes by finding and correcting problems as they occur. • When predicting the expected range of outcomes from a process. • When determining whether a process is stable (in statistical control). • When analyzing patterns of process variation from special causes (non-routine events) or common causes (built into the	which the data were generated by the process. 2. Mark off the data units on the vertical (y) axis and mark the sequence (1, 2, 3…) or time unit on the horizontal (x) axis. 3. Plot the data points on the chart and raw a line connecting them in sequence. 4. Determine the median and draw a line at that value on the chart. 5. Count the number of points not on the median. 6. Circle then count the number of runs. 7. Use a run chart table to interpret the results. Resources: none Expertise: 2		

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	tools. 1998. Available at: http://www.boeing.com/companyoffices/doingbiz/supplier/d1-9000-1.pdf. Accessed August 24, 2009. Roberts L. SPC for right-brain thinkers: process control for non-statisticians. Milwaukee, WI: ASQ Quality Press; 2006. Matthes N, Ogunbo S, Pennington G, et al. Statistical process control for hospitals: Methodology, user education, and challenges. Qual Manag Health Care 2007;16(3):205-14.	process). • When determining whether your quality improvement project should aim to prevent specific problems or to make fundamental changes to the process. • To find baseline performance over time • To find amount/type of variation in process • To determine if process is changing over time • To determine if change really was an improvement • To find more accurate basis for prediction • To graphically display shifts, trends, cycles, or other non-random patterns over time • To identify problems (by showing a trend away from the desired results) • To monitor progress when solutions are carried out • To identify the underlying causes of process malfunction • To keep a continuing record of a particular quality characteristic • To determine process capability • To help determine effective specifications • To investigate causes of unacceptable or marginal quality			

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
Strategic Planning	Scheele K. Too many projects, too little time: How strategic planning helped us focus. 17th Annual Society for Health Systems Management Engineering Forum; 2005; Dallas, TX; 2005. Yeager K. Establishment and utilization of balanced scorecards. In: Roberts A, Yeager K, editors. Evidence-based practice manual: research and outcome measures in health and human services. New York: Oxford University Press; 2004. p. 891-6.	Identifies, organizes and prioritizes the issues in which to commit resources and action, sets targets, and measures achievement over time. Used: • Before beginning a project	1. Analyze the situation 2. Establish strategic direction 3. Define strategies 4. Define each person's job 5. Translate strategy (visualize the process) 6. Create organizational alignment 7. Continue the process Resources: none Expertise: 1	Pros: • Can be used for large and small projects • Keeps tasks, resources, etc. organized Cons: • Strategy is reactive • Can be too vague • No clear accountability assigned • No process	

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Stratification	American Society for Quality. Data collection and analysis tools: Stratification. 2009. Available at: http://www.asq.org/learn-about-quality/data-collection-analysis-tools/overview/stratification.html. Accessed 2009 July 23, 2009. Tague N. The tools. In: O'Mara P, editor. The quality toolbox. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2005. p. 93-521. Bauer J, Duffy G, Westcott R, editors. The quality improvement handbook, Improvement Tools. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2006. p. 109-48.	Stratification is a technique used in combination with other data analysis tools. When data from a variety of sources or categories have been lumped together, the meaning of the data can be impossible to see. This technique separates the data so that patterns can be seen. A technique called stratification is often very useful in analyzing data in order to find improvement opportunities. Stratification helps analyze cases in which data actually mask the real facts. This often happens when the recorded data are from many sources but are treated as one number. The basic idea in stratification is that data that are examined may be secured form sources with different statistical characteristics. Used: • Before collecting data • When data come from several sources or conditions, such as shifts, days of the week, suppliers or population groups • When data analysis may require separating different sources or conditions • To find improvement opportunities	1. Before collecting data, consider which information about the sources of data might have an effect on the results. **Set up data collection** so that information too. 2. When plotting or graphing the collected data **use different marks or colors to distinguish data** from various sources. 3. **Analyze the subsets** of stratified data separately. *Stratification template in ASQ Resources: paired data, spreadsheet software Expertise: 1	Pros: • Allows for data analysis of many sources to be separated and looked at according to those sources • Easy to do	

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Strength, Weakness, Opportunities and Threats (SWOT) Analysis	Medical Group Management Association. Strengths, weaknesses, opportunities and threats (SWOT) analysis Englewood, CO; 2005. Andersen B. Understanding the organization's stakeholders and strategic direction. In: O'Mara P, editor. Business process improvement toolbox. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2007. p. 9-25. Tidd J, Bessant J, Pavitt K. Innovation management toolbox. 2001. Available at: http://www.wiley.co.uk/wileychi/innovate/website/pages/atoz/atoz.htm. Accessed August 24, 2009.	A SWOT analysis is an essential tool to develop business and marketing strategies. It is simply a list of the strengths, weaknesses, opportunities and threats pertaining to your product or service. The SWOT analysis is probably one of the best-known simple strategic techniques that exists. It identifies elements inside the organization and its surroundings within the perspectives of strengths, weaknesses, opportunities, and threats. Its purpose is simply to create an awareness of forces that will impact the organization in the future. By understanding these forces and making them known throughout the organization, better strategic decisions can be made and the whole organization will be better prepared for future developments. Used: • To develop business and marketing strategies	A SWOT analysis is best put into a one-page document so you can compare all four variables in one glance. A SWOT should list only essential items (not a complete, unedited brain dump); and preferably these items are placed in order of priority. A narrative can precede the SWOT analysis to introduce the product or service; the analysis can conclude with a narrative summing up the top issues and provide a rationale for action taken on them in your business and marketing plans. 1. COMPOSE A TEAM to undertake the analysis, drawing on different levels of competence within the organization. Consider supplementing the team with external representatives. 2. For each of the four analysis perspectives, BRAINSTORM ISSUES that seem relevant. 3. COMPILE THE ANALYSIS RESULTS, using a simple table or matrix. 4. DISCUSS which of the issues identified is	Pros: • Allows better strategic decisions to be made • Prepares an organization for future developments. • Technically simple • Can help you uncover opportunities that you are well placed to exploit Cons: • Performing a good SWOT analysis can be difficult	Orillac A. Optimizing workload distribution in the bone marrow transplant unit using structured estimating. 17th Annual Society for Health Systems Management Engineering Forum; 2005; Dallas, TX; 2005.

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			believed to have the strongest influence on the organization's future. 5. OUTLINE STRATEGIES OR ACTIONS to deal with the findings. * SWOT analysis template available on MindTools Resources: none Expertise: 1		

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Survey (Also called: Questionnaire, e-survey)	American Society for Quality. Data collection and analysis tools: Survey. 2009. Available at: http://www.asq.org/learn-about-quality/data-collection-analysis-tools/overview/survey.html. Accessed June 30, 2009. NEDARC. Survey methods, pros & cons. 2006. Available at: http://www.nedarc.org/nedarc/media/pdf/surveyMethods_2006.pdf. Accessed June 30, 2009. Lighter D. Process orientation in health care quality. In: Moore C, editor. Quality management in health care: principles and methods. 2 ed. Sudbury, MA: Jones and Bartlett Publishers; 2004. p. 43-101. George M, Rowlands D, Price M, et al. Voice of the customer. The lean six sigma pocket toolbook. New York: McGraw–Hill; 2005. p. 55-68. Tague N. The tools. In: O'Mara P, editor. The quality toolbox. 2nd ed. Milwaukee, WI: ASQ	Surveys collect data from a targeted group of people about their opinions, behavior or knowledge. Common types of surveys are written questionnaires, face-to-face or telephone interviews, focus groups and electronic (e-mail or Web site) surveys. Surveys are commonly used with key stakeholders, especially customers and employees, to discover needs or assess satisfaction. Surveys are used to get quantitative data across an entire segment or group of segments on customer reactions to a product, service, or attribute. Used: • When identifying customer requirements or preferences. • When assessing customer or employee satisfaction, such as identifying or prioritizing problems to address. • When evaluating proposed changes. • When assessing whether a change was successful. • Periodically, to monitor changes in customer or employee satisfaction over time. • To efficiently gather a considerable amount of information from a large	1. DECIDE WHAT WANT TO LEARN and how results will be used 2. DECIDE WHO SHOULD BE SURVEYED 3. DECIDE ON MOST APPROPRIATE TYPE OF SURVEY 4. DECIDE FORMAT (numerical rating, numerical ranking, yes/no, multiple choice, open-ended, or a mixture) 5. BRAINSTORM QUESTIONS (and possible answers for multiple choice) 6. PRINT QUESTIONNAIRE or interviewers' question list 7. PILOT TEST SURVEY with small group and collect feedback 8. Based on feedback EDIT QUESTIONS, format, etc. Do you have all data you need? 8. FINALIZE THE SURVEY. 9. SEND OUT SURVEY (mail, fax, email attachment) to selected customers. Include a means for them to respond—SASE, return fax number, email reply. Or post on your Web site and give participants instructions	Pros: • Many types of surveys/questionnaires Cons: • Many surveys are poorly written and as a result provide poor feedback • Can be difficult and time consuming to write *Pros and cons depend a lot on type of survey/questionnaire	Young L, Boggs B. Culture changing strategies and cost saving initiatives to improve patient care at a 100-bed inpatient hospital. 17th Annual Society for Health Systems Management Engineering Forum; 2005; Dallas, TX; 2005. McManus K. Do you work in a high performance workplace? 2007 Society for Health Systems Conference; 2007; New Orleans, LA; 2007. Appendix A: Primary care workbook. In: Nelson E, Batalden P, Godfrey M, editors. Quality by design: a clinical microsystems approach. San Francisco: Jossey-Bass; 2007. p. 385-431. Kristensen M, Nøhr C. Technological changes in the health care sector. A method to assess change readiness. In: Hasman A, Blobel B, Dudeck J, et al., editors. Medical Infobahn for Europe: Proceedings of MIE2000 and GMDS2000. The Netherlands: IOS Press; 2000. p. 259-63. Cooper J, Copenhaver J, Copenhaver C. Workflow

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	Quality Press; 2005. p. 93-521 Andersen B. Tools for collecting data about the performance shortcoming. In: O'Mara P, editor. Business process improvement toolkit. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2007. p. 107-22.	population • To conduct analysis that will result in data with statistical validity and integrity • When you need or want to contact many customers to get quantitative information • As prework for interviews or focus groups to identify target areas for more in-depth investigation • As follow-up to interviews or focus group to quantify relationships or patterns identified	on how to access the survey. 10. COMPILE AND ANALYZE THE RESULTS. 1. Decide what want to learn and how results will be used 2. Decide who should be surveyed 3. Decide on most appropriate type of survey 4. Decide format (numerical rating, numerical ranking, yes/no, multiple choice, open-ended, or a mixture) 5. Brainstorm questions (and possible answers for multiple choice) 6. Print questionnaire or interviewers' question list 7. Pilot test survey with small group and collect feedback 8. Based on feedback edit questions, format, etc. Do you have all data you need? 1. Develop survey objectives. 2. Determine the required sample size. 3. Write draft questions and determine measurement scales. 4. Determine how to code surveys so data		in the primary care physician's office: a study of five practices. In: Kiel JM, editor. Information technology for the practicing physician. New York: Springer; 2001. p. 22-34. HealthInsight, Medicare quality improvement organization for Utah and Nevada, Illinois Foundation for Quality Heath Care. Illinois Foundation for Quality HealthCare: Workflow assessment. 2007. Available at: http://www.ifqhc.org/provider/documents/workflow_assessment.pdf. Accessed June 19, 2009. Full Circle Projects I. Health information technology self assessment. 2009. Available at: http://www.coloradohealth.org/WorkArea/showcontent.aspx?id=2532. Accessed 2009 June 23, 2009. Masspro. A systems approach to operational redesign. 2006. Available at: http://www.masspro.org/HIT/PFQ/docs/tools/DOQIT WB for WEB.pdf. Accessed June 26, 2009.

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			can remain anonymous. 5. Design the survey. 6. Confirm that getting answers to the individual questions will meet your objectives (adjust, if not). 7. Conduct a pilot test. 8. Finalize the survey. 9. Send out survey (mail, fax, email attachment) to selected customers. Include a means for them to respond—SASE, return fax number, email reply. Or post on your Web site and give participants instructions on how to access the survey. 10. Compile and analyze the results. 1. Clearly define the objective of the survey and how the data will be used later. 2. Determine what information is required to achieve this objective. 3. Decide how the survey will be undertaken—that is, written (via mail, fax, e-mail, or the internet) or verbal (by telephone or in person). 4. Develop the questionnaire, keeping in mind issues such as type and sequence of questions,		Masspro, Medicare Quality Improvement Organization for Massachusetts, Illinois Foundation for Quality Heath Care, et al. Operational Redesign Through Workflow. 2007. Available at: http://www.ifqhc.org/provider/documents/operational_redesign_patient_flow_worksheet.pdf. Accessed June 19, 2009. Walker J, Bieber E, Richards F, et al. Appendix 5: Site characteristics questionnaire. In: Walker J, Bieber E, Richards F, editors. Implementing an electronic health record system. London: Springer; 2005. p. 198-9. Walker J, Bieber E, Richards F, et al. Appendix 11: Practice-analysis checklist. In: Walker J, Bieber E, Richards F, editors. Implementing an electronic health record system. London: Springer; 2005. p. 224-5. Medical Group Management Association. EHR practice readiness assessment. Englewood,

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			understandability, language, grouping of questions, brevity, and so on. 5. Test the questionnaire to ensure that all questions are easy to understand and can measure what they are intended to. 6. Identify the sample of respondents. 7. Perform the survey according to the chosen approach. Resource: none Expertise: 1		CO 2005. Trivedi M, Kern J, Marcee A, et al. Development and implementation of computerized clinical guidelines: Barriers and solutions. Methods of Information in Medicine 2002;41(5):435-42.

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
Tabular Task Analysis (TTA)	Stanton N, Salmon P, Walker G, et al. Task analysis methods. Human factors methods: a practical guide for engineering and design. Great Britain: Ashgate; 2005. p. 45-76.	Tabular task analysis (TTA) can be used to analyze a particular task or scenario in terms of the required task steps and the interface used. A TTA takes each bottom level task step from a HTA and analyzes specific aspects of the task step, such as displays and controls used, potential errors, time constraints, feedback, triggering events etc. The content and focus of the TTA is dependent upon the nature of the analysis required. Used: • To analyze a particular task or scenario in terms of the required task steps and the interface used	1. DEFINE THE TASK(S) UNDER ANALYSIS. The first step in a TTA involves defining the task or scenario under analysis. The analyst firstly should specify the task(s) that are to be subjected to the TTA. A task or scenario list should be created, including the task, system, environment and personnel involved. 2. COLLECT SPECIFIC DATA REGARDING THE TASK(S) UNDER ANALYSIS. Once the task under analysis is defined, the data that will inform the development of the TTA should be collected. Specific data regarding the task should be collected, including task steps involved, task sequence, technology used, personnel involved, and communications made. There are a number of ways available to collect this data, including observations, interviews, and questionnaires. It is recommended that a combination of observation of the task under analysis and interviews with the	Pros: • TTA is a flexible method, allowing any factors associated with the task to be assessed • A TTA analysis has the potential to provide a very comprehensive analysis of a particular ask or scenario • Easy to learn and use • Method is generic and can be used in any domain • TTA provides a much more detailed description of tasks than traditional task analysis can be evaluated • Potentially exhaustive, if the correct categories are used Cons: • As the TTA is potentially so exhaustive, it is a very time consuming method to apply. The initial data collection phase and the development of a HTA for the task under analysis also add considerably to the overall application time. • Data regarding the reliability and validity of the method is not available in the literature. It is logical to assume that the method may suffer from problems surrounding the reliability of the data produced. • A HTA for the task under analysis may suffice in most cases	

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			personnel involved should be used when conducting a TTA. 3. CONDUCT A HIERARCHICAL TASK ANALYSIS (HTA) FOR THE TASK UNDER ANALYSIS. Once sufficient data regarding the task under analysis is collected, an initial task description should be created. For this purpose it is recommended that HTA is used. The data collected during step 2 should be used as a primary input to the HTA. 4. CONVERT HTA INTO TABULAR FORMAT. Once an initial HTA for the task under analysis has been conducted, the analyst should put the HTA into a tabular format. Each bottom level task step should be placed in a column running down the left hand side of the table. 5. CHOOSE TASK ANALYSIS CATEGORIES. Next the analyst should select the appropriate categories and enter them into the TTA. The selection of categories is dependent upon the nature of the analysis.		

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			6. COMPLETE TTA TABLE. Once the categories are chosen, the analyst should complete the columns in the TTA for each task. How this is achieved is not a strictly defined process. A number of methods can be used, such as walkthrough analysis, heuristic evaluation, observations or interviews with subject matter experts (SMEs). Typically, the TTA is based upon the analyst's subjective judgment. Resources: spreadsheet software Expertise: 1		

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Task Decompositi on	Stanton N, Salmon P, Walker G, et al. Task analysis methods. Human factors methods: a practical guide for engineering and design. Great Britain: Ashgate; 2005. p. 45-76.	Task decomposition involves describing the task or activity under analysis and then using specific task-related information to decompose the task in terms of specific statements regarding the task. The task can be decomposed to describe a variety of task-related features, including the devices and interface components used, the time taken, errors, made, feedback and decisions required. The categories used to decompose the task steps should be chosen by the analyst based on the requirements of the analysis. There are numerous decomposition categories that can be used and new categories can be developed if required by the analysis. Used: • To gather detailed information regarding a particular task or scenario • To describe a variety of task-related features, including the devices and interface components used, the time taken, errors, made, feedback and decisions required	1. HIERARCHICAL TASK ANALYSIS. The first step in a task decomposition analysis involves creating an initial description of the task or scenario under analysis. It is recommended that a HTA is conducted for this purpose, as a goal driven, step-by-step description of the task is particularly useful when conducting a task decomposition analysis. 2. CREATE TASK DESCRIPTIONS. Once an initial HTA for the task under analysis has been conducted, the analyst should create a set of clear task descriptions for each of the different task steps. These descriptions can be derived from the HTA developed during step 1. The task description should give the analyst enough information to determine exactly what has to be done to complete each task element. The detail of the task descriptions should be determined by the requirements of the analysis. 3. CHOOSE DECOMPOSITION CATEGORIES. Once a sufficient description of	Pros: • Task decomposition is a very flexible approach. In selecting which decomposition categories to use, the analyst can determine the direction and focus of the analysis. • A task decomposition analysis has the potential to provide a very comprehensive analysis of a particular task • Task decomposition techniques are easy to learn and use • The method is generic and can be used in any domain • Task decomposition provides a much more detailed description of tasks than traditional task analysis methods do • As the analyst has control over the decomposition categories used, potentially any aspect of a task can be evaluated. In particular, the method could be adapted to assess the cognitive components associated with tasks (goals, decisions, SA). Cons: • As the task analysis is potentially so exhaustive, it is a very time consuming method to apply and analyze. The HTA only serves to add to the high application time. Furthermore, obtaining information about the tasks (observation, interview etc)	

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			each task step is created, the analyst should choose the appropriate decomposition categories. Thereare three types of decomposition categories: descriptive, organization-specific and modeling. 4. INFORMATION COLLECTION. Once the decomposition categories have been chosen, the analyst should create a data collection pro-forma for each decomposition category. The analyst should then work through each decomposition category, recording task descriptions and gathering the additional information required for each of the decomposition headings. There are many possible methods to gather this information, including observation, system documentation, procedures, training manuals and discussions with system personnel and designers. Interviews, questionnaires, VPA and walkthrough analysis can also be	creates even more work for the analyst • Task decomposition can be laborious to perform, involving observations, interviews etc	

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			used. 5. CONSTRUCT TASK DECOMPOSITION. The analyst should then put data collected into a task decomposition output table. The table should comprise all of the decomposition categories chosen for the analysis. The amount of detail included in the table is also determined by the scope of the analysis. Resources: none Expertise: 1		

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Time and Motion Study (Also called: Process Observation Worksheet, Time-motion study, Time study)	Woodward H, Suskovich D, Workman-Germann J, et al. Adaptation of lean methodologies for health care applications. 2007 Society for Health Systems Conference; 2007; New Orleans, LA; 2007. Backer LA. Strategies for better patient flow and cycle time. Family Practice Management 2002 June;9(6):45-50. Coleman Associates. Patient visit tracking toolkit: A bird's eye view of the patient experience. 2007. Available at: http://www.patientvisitredesign.com/docs/Visit_Tracking_ToolKit_1.pdf. Accessed July 9, 2009. Coleman Associates. The baseline data advisory: Documenting your starting point statistically. 2007. Available at: http://www.patientvisitredesign.com/docs/Baseline_Data_ToolKit_6_26_05.pdf. Accessed July 9, 2009.	A data collection tool used during process observation to collect times and durations for individual process steps. Builds on flow mapping and involves measuring and charting the time associated with various parts of the patient visit. To collect times and durations for individual process steps	In determining what to measure, you can be detailed, take a high-level view of the visit or aim for something in between. Most important, the measures should distinguish waiting time from the rest of the visit. Once you've decided what to measure, you'll need to decide on a sampling method and determine who will do the measurement. For example, you might choose to measure cycle time for patients scheduled at 10 a.m. and 3 p.m. once a week for each physician. Resources: stopwatch Expertise: 1	Pros: • Builds confidence in the reliability and repeatability of collected data	Yen K, Shane EL, Pawar SS, et al. Time motion study in a pediatric emergency department before and after computer physician order entry. Ann Emerg Med 2008;53(4):462-8. Institute for Healthcare Improvement. Tools: Patient cycle tool. 2009. Available at: http://www.ihi.org/IHI/Topics/OfficePractices/Access/Tools/Patient+Cycle+Tool+IHI+Tool.htm. Accessed July 9, 2009. Hollingworth W, Devine E, Hansen R, et al. The impact of e-Prescribing on prescriber and staff time in ambulatory care clinics: A time-motion study. J Am Med Inform Assoc 2007;14(6):722-30.

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Time Value Maps (Also called value-added time analysis)	George M, Rowlands D, Price M, et al. Value stream mapping and process flow tools. The lean six sigma pocket toolbook. New York: McGraw–Hill; 2005. p. 33-54.	Time value maps are a visual depiction of value-add and non-value-add time in a process. Used: • To visually depict value-add and non-value-add time in a process	1. DETERMINE PROCESS CYCLE TIME. 2. DETERMINE QUEUE TIMES (delays) between steps and the value-add time needed to perform each task. 3. DRAW A TIMELINE and divide into units equal to the total process time. 4. PLACE STEPS AND DELAYS ALONG THE TIMELINE in the order in which they happen; use segments proportional to the times. VA steps go above the line. NVA goes below the line. The white space between boxes indicates queue or delay times. 5. DRAW IN FEEDBACK LOOPS and label yield percentages. 6. SUMMARIZE TIME USE. Resources: none Expertise: 1	Pros: Give a better impression of overall cycle time than Value-add chart.	Brock J, Batchelor E. Discussion with Dr. Jane Brock and Ellen Batchelor of the Colorado Foundation for Medical Care on July 28, 2009. In: Hundt A, Cartmill R, editors.: Center for Quality and Productivity Improvement; 2009. p. 1-3.

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Top-down Flowchart	Lighter D. Process orientation in health care quality. In: Moore C, editor. Quality management in health care: principles and methods. 2 ed. Sudbury, MA: Jones and Bartlett Publishers; 2004. p. 43-101.	Orders the steps of a process by importance. It provides an overview of the process steps ranked by the improvement team or by those responsible for implementing the process, providing helpful information for allocating scarce resources to a project and ensuring that adequate resources are available for critical steps before the process is initialized. Used: • To order steps of a process by importance • As a quick way to flowchart an existing process that has seemingly grown to unexpected proportions because it prioritizes steps and simplifies the task of re-engineering the process	1. DEFINE THE PROCESS and put the major steps of the process in boxes at the top of a page. 2. DETERMINE SUBPROCEDURES for each of the major steps and list them in order below each major step. 3. CONNECT THE PROCEDURES AND SUBPROCEDURES using arrows as in a typical flowchart. 4. SEEK INPUT REGARDING THE HIERARCHY OF STEPS from those who will implement the process. Resources: sticky notes, flip chart Expertise: 1	Pros: • Can direct quality improvement efforts by focusing on crucial stages and ensuring that all subprocedures are included in process planning • Provides information that can identify sources of waste and rework	

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
Tree Diagram (Also called: systematic diagram, tree analysis, analytical tree, hierarchy diagram, structured-tree diagram)	American Society for Quality. Seven new management and planning tools: Tree diagram. 2009. Available at: http://www.asq.org/learn-about-quality/new-management-planning-tools/overview/tree-diagram.html. Accessed July 23, 2009. Lighter D. Process orientation in health care quality. In: Moore C, editor. Quality management in health care: principles and methods. 2 ed. Sudbury, MA: Jones and Bartlett Publishers; 2004. p. 43-101. Tague N. The tools. In: O'Mara P, editor. The quality toolbox. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2005. p. 93-521. Bauer J, Duffy G, Westcott R, editors. The quality improvement handbook, Improvement Tools. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2006. p. 109-48. Andersen B. Tools for implementing improvements. In:	The tree diagram starts with one item that branches into two or more, each of which branch into two or more, and so on. It looks like a tree, with trunk and multiple branches. It is used to break down broad categories into finer and finer levels of detail. Developing the tree diagram helps you move your thinking step by step from generalities to specifics. Provides a logical framework for organizing complex systems or illustrating the branching logic of a decision support system. It presents complex decision paths in relatively straightforward graphical diagrams and can be used to provide an overview of complex processes. A tree diagram is a graphic representation of the separation of broad, general information into increasing levels of detail. The tool ensures that action plans remain visibly linked to overall goals, that actions flow logically from identified goals, and that the true level of a project's complexity will be fully understood. The Structure-Tree diagram graphically represents the hierarchical relationship	1. DEVELOP A STATEMENT of goal, project, plan, problem, or whatever is being studied. Write at top of work surface. 2. ASK A QUESTION THAT WILL LEAD TO NEXT LEVEL OF DETAIL. (Ex. For a root-cause-analysis: "What causes this?") Brainstorm all possible answers and right on lines. Link answers with arrows. 3. DO A "NECESSARY AND SUFFICIENT" CHECK. Are items on this level necessary and sufficient for the level above? 4. Each of the answers now becomes the new subject (goal, objective, etc.). DO STEPS 2 AND 3 AGAIN for the new subjects to uncover the next level of detail. 5. CONTINUE TO TURN EACH NEW IDEA INTO A SUBJECT STATEMENT and ask the question. Do not stop until you reach fundamental elements: specific actions that can be carried out, components that are not divisible, root causes. 6. DO A "NECESSARY AND SUFFICIENT" CHECK of the entire	Pros: • Can be applied to several types of problems • Provides a logical framework for organizing complex systems • Illustrates the branching logic of a decision support system • Helps identify key characteristics and key process parameters • Illustrates the various causes affecting a process problem • Helps a team reach a common understanding of a problem or situation • Exposes gaps in existing knowledge of problem or situation • Helps reduce the incidence of uninformed decisionmaking	

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	O'Mara P, editor. Business process improvement toolbox. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2007. p. 237-49. The Boeing Company. Advanced quality system tools. 1998. Available at: http://www.boeing.com/companyoffices/doingbiz/supplier/d1-9000-1.pdf. Accessed August 24, 2009.	among a group of related parts, processes, activities, key characteristics, causes and effects, people, or most anything else. This tool is often used in lieu of the cause and effect diagram due to its ease of understanding, flexibility, and readability. Used: • To move from a general concept or goal to specific actions or details • When there are many possible ways to achieve a goal or the objective is very complex • To provide an overview of complex processes • When an issue is known or being addressed in broad generalities and you must move to specific details • When developing logical steps to achieve an objective • When developing actions to carry out a solution or other plan • When analyzing processes in detail • When probing for the root cause of a problem • When evaluating implementation issues for several potential solutions • After an affinity diagram or relations diagram has uncovered key issues • As a communication tool, to explain details to others	diagram. Are all the items necessary for the objective? If all the items were present or accomplished, would they be sufficient for the objective? 1. Define the goal of the diagram. This step is usually performed by the organization during strategic planning sessions or by mandate from senior management. 2. Determine what steps need to occur to achieve the goal. If there are more than five or six steps, the project should be redefined to keep the number of branches on the tree manageable. 3. After these possibilities are defined, each is further dissected into more branches until the team feels that the tree is complete, i.e., the ends of the branches represent specific actions to be accomplished. 4. After all of the branches have been defined, the team re-evaluates the tree to ensure that each task shows all the actions necessary to complete the task. Additionally, the team should		

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		• Performing key characteristic flowdown • Looking for all potential causes of a problem • Organizing brainstorming lists in to a logical hierarchy • Identifying sources of process variation • Breaking down an assembly into subassemblies, details, and processes • Problem solving; root-cause analysis	evaluate all actions to confirm that each is necessary to accomplish the goal. 5. Include implementation teams in the planning process to determine if each action is achievable. 1. *Identify the goal statement or primary objective*. This should be a clear action-oriented statement to which the entire team agrees. Such statements may come from the root cause/driver identified in an interrelationship digraph or from the headings of an affinity diagram. Write this goal on the extreme left of the chart. 2. *Subdivide the goal statement into major secondary categories*. These branches should represent goals, activities, or events that directly lead to the primary objective or that are directly required to achieve the overall goal. The team should continually ask, "What is required to meet this condition?" "What happens next?" and "What needs to be addressed?" Write the		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
			secondary categories to the right of the goal statement. Using sticky notes at this stage makes later changes easier to accomplish. 3. *Break each major heading into greater detail*. As you move from left to right in the tree, the tasks and activities should become more and more specific. Stop the breakdown of each level once there are assignable tasks. If the team does not have enough knowledge to continue at some point, identify the individuals who can supply the information and continue the breakdown later with those individuals present. 4. *Review the diagram for logic and completeness*. Make sure that each subheading and path has a direct cause-and-effect relationship with the one before. Examine the paths to ensure that no obvious steps have been left out. Also ensure that the completion of listed actions will indeed lead to the anticipated results. 1. Generate a list of		

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			activities that must be performed to implement the improvement proposals. 2. On sticky notes, write down each activity in the form of a verb followed by a noun. 3. Arrange the activities in logical subgroups that must be performed in sequence. 4. Arrange the subgroups in an overall sequence to illustrate the entire plan in the tree diagram. Resources: none Expertise: 1		

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
Usability Evaluation (Also called: Usability Testing)	Healthcare Information and Management Systems Society. Defining and testing EMR usability: Principles and proposed methods of EMR usability evaluation and rating. 2009. Available at: http://www.himss.org/content/files/HIMSS_DefiningandTestingEMRUsability.pdf Accessed September 14, 2009. Center for Quality and Productivity Improvement. CPOE usability resources. 2010. Available at: http://cqpi.engr.wisc.edu/cpoe_usability. Accessed May 25, 2010.	A usability evaluation is a tool for determining the extent to which a system is easy to use or "user friendly." Usability is the effectiveness, efficiency and satisfaction with which specific users can achieve a specific set of tasks in a particular environment. In essence, a system with good usability is easy to use and effective. It is intuitive, forgiving of mistakes and allows one to perform necessary tasks quickly, efficiently and with a minimum of mental effort. Used: • Prior to procuring a system to compare systems from which purchaser has to choose • During the design phase of the system to obtain user feedback and obtain design suggestions • During the design phase to determine the system's impact on workflow • After implementation of a system to identify necessary improvements	1. Determine the goal and the specific objective of evaluation—specifically, what will be evaluated? 2. Identify individual(s) who will lead/conduct the evaluation. 3. Identify target users and recruit participants. 4. Determine specific method(s) to use for capturing what you want to evaluate (e.g. heuristic evaluation, scenario-driven evaluation, post-use survey/focus group) and how you will collect/record the results. 5. Evaluate results of evaluation and determine how to address findings (e.g., system redesign, training, workflow modification). Resources: Data collection instruments Expertise: 2	Pros: • Can identify design/use issues and determine how to address them prior to implementation of the system Cons: • Planning required may be extensive if objectives are too ambitious or not clearly defined	Rodriguez NJ, Borges JA, Soler Y, et al. A usability study of physicians' interaction with PDA and laptop applications to access an electronic patient record system. In: Long R, Antani S, Lee DJ, Nutter B, Zhang M, editors. 17th IEEE Symposium on Computer-Based Medical Systems: Proceedings CBMS 2004; 2004; Quincy, Florida The Printing House; 2004. p. 153-60. Walker J. Usability. In: Walker J, Bieber E, Richards F, editors. Implementing an electronic health record system. London: Springer; 2005. p. 47-59. Marcy T, Kaplan B, Connolly S, et al. Developing a decision support system for tobacco use counselling using primary care physicians. Inform Prim Care 2008;16(2):101-9.

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
Use Case	Scheele K. Improving patient results tracking in a multi-specialty clinic. 2007 Society for Health Systems Conference; 2007; New Orleans, LA; 2007. Gee T. The challenge of automating workflow. 2008. Available at: http://medicalconnectivity.com/2008/10/28/the-challenge-of-automating-workflow/. Accessed May 20, 2009. Sharp A, McDermott P. Requirements modeling with use cases and services. Workflow modeling: tools for process improvement and applications development. 2nd ed. Boston: Artech House; 2009. p. 375-422.	A methodology used in system analysis to identify, clarify, and organize system requirements. The use case is made up of a set of possible sequences of interactions between systems and users in a particular environment and related to a particular goal. It consists of a group of elements (for example, classes and interfaces) that can be used together in a way that will have an effect larger than the sum of the separate elements combined. The use case should contain all system activities that have significance to the users. A use case can be thought of as a collection of possible scenarios related to a particular goal, indeed, the use case and goal are sometimes considered to be synonymous. A use case (or set of use cases) has these characteristics: Organizes functional requirements Models goals of system/actor (user) interactions Records paths (called *scenarios*) from trigger events to goals Describes one main flow of events and possibly other ones, called *exceptional* flows of events (also called alternate courses of action)	1. IDENTIFY SERVICES (SCOPE) and complete initial service specifications (concept). 2. IDENTIFY USE CASES (SCOPE) and complete initial use case descriptions (concept). 3. COMPLETE FINAL SERVICE SPECIFICATIONS (DETAIL). 4. BEGIN FINAL USE CASE DESCRIPTIONS (first pass at detail). 5. Refine final use case descriptions (final pass at detail). 6. IDENTIFY AND DESCRIBE USE CASE SCENARIOS (conditions and outcomes). 7. COMPLETE USE CASE SCENARIO DESCRIPTIONS (dialogues). Refine use cases as necessary. Resources: none Expertise: 2	Pros: • Does not require a team to use • Much more likely to uncover requirements that would be missed in less specific approaches • By taking the use case down to a series of steps, or a back-and-forth dialogue, you are more likely to develop an effective and workable interaction before beginning application design and development Cons: • Some clinical background is necessary to capture good results (for health centers)	

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		Comparative tool that describe a detailed process by interviewing, observation (of the people and events) in order to see how the implementation of system would affect the process or to compare with another system. A use case is a step-by-step set of instructions that an actor (person in a process) completes at a single time and place to accomplish a step in a process. A use case is a single case in which a specific actor will use a system to obtain a particular business service from the system. A use case is documented in a use case description which traces a generalized sequence of interactions between the actor and the system. Eventually, those interactions will be described right down to a “back and forth” dialogue that the actor will go through to obtain the service. The orientation is *who* the particular actor is, and *how* that actor will interact with a system, in order to obtain the desired service. Most important, a use case describes system behavior *from the perspective of the actor* interacting with the system.			

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
		Used: • To determine how a system will help a specific actor complete a specific activity or process step • Can be used during several stages of software development, such as planning system requirements, validating design, and testing software.			

Name of tool and acronym	Educational References	Purpose and timing of tool	How Do I Use This Tool?	Advantages and disadvantages of tool	Example References
Value Stream Mapping	Koelling C, Eitel D, Mahapatra S, et al. Value stream mapping the emergency department. 17th Annual Society for Health Systems Management Engineering Forum; 2005; Dallas, TX; 2005. Bhagat A, Wang S, Khasawneh MT, et al. Enhancing hospital health information management using industrial engineering tools. 2008. Available at: [http://www.iienet2.org/uploadedFiles/SHS_Community/Enhancing Hospital Health Information Management using Industrial Engineering Tools.pdf](http://www.iienet2.org/uploadedFiles/SHS_Community/Enhancing%20Hospital%20Health%20Information%20Management%20using%20Industrial%20Engineering%20Tools.pdf). Accessed May 20, 2009. Nagaraju D. Improvement of hospital discharge process by value stream mapping. 17th Annual Society for Health Systems Management Engineering Forum; 2005; Dallas, TX; 2005. O'Quinn P, Pondhe R. Finding opportunities in pre-admission testing through value stream mapping. 2007 Society for Health Systems Conference; 2007; New	VSM is an enterprise wide improvement technique that helps visualize the entire process, representing material and information flow, to improve production or service processes by identifying waste and its sources. It identifies all the actions (both value added and non value added) required to bring a specific product, service or a combination of products and services, to a customer. A strategic management diagnostic tool that focuses on providing a representation of a specific operation or a portion of an operation from a localized or tactical perspective. A mapping tool that identifies not only material flow but also the information flow that greatly reduces the cost and processing time. It applies a two-phase approach, Current state and Future state, to identify the value added activities and tries to eliminate wastes (non-value-added activities). A value stream map (VSM) is similar to a process map, but includes some additional details such as information flow and a quality indicator. There are two types of VSM's: current stat map and	1. Identify relevant product families and select one as the target. 2. Construct a current state map for the product value stream using info gathered from actual production process. 3. Map future state. 1. Define product family 2. Document current state 3. Design future state 4. Create Implementation plan 5. Implement 6. Repeat 1. DETERMINE WHAT INDIVIDUAL PRODUCT, SERVICE, OR FAMILY YOU WILL MAP. 2. DRAW THE PROCESS FLOW. 3. ADD THE MATERIAL FLOW. 4. ADD THE INFORMATION FLOW. Document how the process communicates with the customer and supplier. Document how information is gathered (electronic, manual, "go look," etc.) 5. COLLECT PROCESS DATA and connect it to the boxes on the chart. 6. ADD PROCESS AND LEAD TIME DATA to	Pros: • Presents "big picture" of process • Visually shows waste and areas that need improvement • Shows linkage between information and material flow • Makes the disconnects and obstacles to flow stand out • Reveals hidden symptoms of larger problems • Strategic planning activity; not tactical • Helps prioritize opportunities for improvement • Results in an implementation plan • Promotes systems-thinking/seeing the whole • Quick and efficient method Cons:	Young, L. and B. Boggs. Culture changing strategies and cost saving initiatives to improve patient care at a 100-bed inpatient hospital. 17th Annual Society for Health Systems Management Engineering Forum, Dallas, TX: 2005. Smith M, Cunningham S. Case study: using lean principles, how Charleston area medical center ED was able to reduce wait time by 95%. 2007 Society for Health Systems Conference; 2007; New Orleans, LA; 2007. Exline K, Martin V. Using lean six sigma to reduce surgery cancellation rate. 2007 Society for Health Systems Conference; 2007; New Orleans, LA; 2007.

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	Orleans, LA; 2007. Woodward H, Suskovich D, Workman-Germann J, et al. Adaptation of lean methodologies for health care applications. 2007 Society for Health Systems Conference; 2007; New Orleans, LA; 2007. Woodcock, E. (2009). The lean-thinking revolution. Mastering patient flow: using lean thinking to improve your practice operations. . . Englewood, Medical Group Management Association: 11-40. George, M., D. Rowlands, et al. (2005). Value stream mapping and process flow tools. The lean six sigma pocket toolbook. New York, McGraw—Hill: 33-54. Zidel, T. (2006). Value stream mapping. A lean guide to transforming healthcare. P. O'Mara. Milwaukee, WI, ASQ Quality Press: 27-44. Rother, M. and J. Shook (2003). Learning to see: value-stream mapping to create value and eliminate muda.	future state map. A Value Stream Map is used to summarize the information collected by the other process observation tools. Information and material flow may be added to provide a complete snapshot of each processing step. Value stream maps are used to capture all key flows (of work, information, materials, etc.) in a process and important process metrics. Value stream maps are more complicated to construct than other flowchart, but much more useful for identifying and quantifying waste (especially in time and costs). Value stream mapping (VSM) uses symbols to create a map of the patient or product flow through the organization and the flow of information associated with the patient or product. The value stream map differs from a flow chart or process map in that it provides valuable information associated with the flow of the process. A value stream is all the actions (both value added and non-value added) currently required to bring a product through the main	the chart. Include delays (queue times), processing (value-add) time, setup time, etc. 7. VERIFY THE MAP. Resources: none Expertise: 1		

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	Cambridge, MA, The Lean Enterprise Institute.	flows essential to every product: (1) the production flow from raw material into the arms of the customer, and (2) the design flow from concept to launch. Used: • When you want to reduce any type of waste in a process • When you need to locate bottleneck in a process • When you want to identify opportunities for future improvement efforts • When you have a limited time to document a process and find problem areas • At the business (strategic) level by management teams and deployment champions for opportunity and project identification • To create an "as-is" version at the project (tactical) level in Define and Measure (of the DMAIC process) to identify and visualize the improvement opportunities • To assess the impact of multiple products or services			

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Value-Added Analysis	Tague N. The tools. In: O'Mara P, editor. The quality toolbox. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2005. p. 93-521.	Value-added analysis is a way of studying a process to identify problems. The analysis helps a team look critically at individual steps of a process to differentiate those that truly add value for the customer from those that do not. Used: • When flowcharting a process, to be sure that non-value-added activities are included • When analyzing a flowchart to identify all possible waste in a process	1. OBTAIN OR CREATE A DETAILED FLOWCHART OR DEPLOYMENT FLOWCHART of the process. 2. For each step ASK THE FOLLOWING QUESTIONS: Is this activity necessary to produce output? Does it contribute to customer satisfaction? If the answer to both questions is yes, then label or color-code (green) the step as real value-adding (RVA). 3. If the answer was no to either question, ASK THIS: Does this activity contribute to the organization's needs? If the answer is yes, then label or color-code (yellow) the step as organizational value-adding (OVA). 4. If the answer to all questions is no, then LABEL OR COLOR-CODE (red) the step as non-value-adding (NVA). 5. (Optional) For each step, DETERMINE THE AMOUNT OF TIME REQUIRED and/or the cost. Determine totals for each category and for the entire process. Determine what fraction		

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			or percent of the total time and/or cost is spent in real value-added activities. 6. STUDY THE NON-VALUE-ADDED ACTIVITIES to reduce or eliminate them. 7. STUDY ORGANIZATIONAL VALUE-ADDING ACTIVITIES to reduce or eliminate them. Resources: none Expertise: 1		

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Verbal Protocol Analysis (VPA)	Stanton N, Salmon P, Walker G, et al. Task analysis methods. Human factors methods: a practical guide for engineering and design. Great Britain: Ashgate; 2005. p. 45-76.	Verbal protocol analysis (VPA) is used to derive descriptions of the processes, cognitive and physical, that an individual uses to perform a task. VPA involves creating a written transcript of operator behavior as they perform the task or scenario under analysis. The transcript is based upon the operator "thinking aloud" as they conduct the task under analysis. Used: • As a means of gaining an insight into the cognitive aspects of complex behaviors	1. DEFINE SCENARIO UNDER ANALYSIS. Firstly, the scenario under analysis should be clearly defined. It is recommended that a hierarchical task analysis is used to describe the task under analysis. 2. INSTRUCT/TRAIN THE PARTICIPANT. Once the scenario is clearly defined, the participant should be briefed regarding what is required of them during the analysis. What they should report verbally is clarified here. It is particularly important that the participant is informed that they should continue talking even when what they are saying does not appear to make much sense. A small demonstration should also be given to the participant at this stage. A practice run may also be undertaken. 3. BEGIN SCENARIO AND RECORD DATA. The participant should begin to perform the scenario under analysis. The whole scenario should be audio recorded (at least) by the analyst. It is also		

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			recommended that a video recording be made. 4. VERBALIZATION OF TRANSCRIPT. Once collected, the data should be transcribed into a written form. An excel spreadsheet is normally used. This aspect of VPA is particularly time consuming and laborious. 5. THE VERBAL TRANSCRIPTS (WRITTEN FORM) SHOULD THEN BE CATEGORIZED OR CODED. Depending upon the requirements of the analysis, the data is coded into one of the following categories; words, word senses, phrases, sentences or themes. The encoding scheme chosen should then be encoded according to a rationale determined by the aims of the analysis. This involves attempting to ground the encoding scheme according to some established theory or approach, such as mental workload or situation awareness. The analyst should also develop a set of written instructions for the encoding scheme.		

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			These instructions should be strictly adhered to and constantly referred to during the encoding process. Once the encoding type, framework and instructions are completed, the analyst should proceed to encode the data. Various computer software packages are available to aid the analyst with this process. 6. Once the encoding is complete, the analyst should DEVISE ANY 'OTHER' DATA COLUMNS. This allows the analyst to note any mitigating circumstances that may have affected the verbal transcript. 7. ESTABLISH INTER AND INTRA-RATER RELIABILITY. Reliability of the encoding scheme then has to be established. In VPA, reliability is established through reproducibility i.e. independent raters need to encode previous analyses. 8. PERFORM PILOT STUDY. The protocol analysis procedure should now be tested within the context of a		

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			small pilot study. This will demonstrate whether the verbal data collected is useful, whether the encoding system works, and whether inter and intra-rater reliability are satisfactory. Any problems highlighted through the pilot study should be refined before the analyst conducts the VPA for real. 9. ANALYZE STRUCTURE OF ENCODING. Finally, the analyst can analyze the results from the VPA. During any VPA analysis the responses given in each encoding category require summing, and this is achieved simply by adding up the frequency of occurrence noted in each category. Thestructure of encodings can be analyzed contingent upon events that have been noted in the 'other data' column(s) of the worksheet, or in light of other data that have been collected simultaneously. Resource: video recording equipment, spreadsheet software		

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			Expertise: 3		

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Workflow Diagram (Also called: Spaghetti Diagram, Transportation Diagram, Work-Flow Diagram, Geographic Flowchart, Physical Layout Flowchart)	Woodward H, Suskovich D, Workman-Germann J, et al. Adaptation of lean methodologies for health care applications. 2007 Society for Health Systems Conference; 2007; New Orleans, LA; 2007. George M, Rowlands D, Price M, et al. Value stream mapping and process flow tools. The lean six sigma pocket toolbook. New York: McGraw–Hill; 2005. p. 33-54. Tague N. The tools. In: O'Mara P, editor. The quality toolbox. 2nd ed. Milwaukee, WI: ASQ Quality Press; 2005. p. 93-521. Lighter D. Process orientation in health care quality. In: Moore C, editor. Quality management in health care: principles and methods. 2 ed. Sudbury, MA: Jones and Bartlett Publishers; 2004. p. 43-101.	A workflow diagram is a picture that shows movement through a process. That movement might be of people, materials, paper, or information. The diagram consists of a map (such as a floor plan) of the area where the process takes place and lines showing all movements. The diagram graphically shows redundant motion and inefficiency. Spaghetti Diagrams are used to represent the physical flow of work for a process. Repeated instances of direct observation are used to capture staff, patient and/or material flow during patient treatment processes. Diagram that depicts the physical flow of work or material in a process. Used to improve the physical layout of a workspace (office, factory, warehouse) or a work form. A work-flow diagram is a picture that shows movement through a process. That movement might be of people, materials, paper, or information. The diagram consists of a map (such as a floor plan) of the area where the process takes place and	1. Find or create a diagram of the workspace. 2. Work from an existing flowchart of the process steps or brainstorm a list of steps. 3. Mark where the first step of the process happens, draw an arrow from there to where the second step happens, etc. Continue until you have mapped all process steps. 4. Discuss the final diagram with an aim towards improving the workflow. 1. DECIDE WHAT IT IS THAT MOVES. This may be paper, a file, a person, a piece of information, or materials. 2. DETERMINE THE RELEVANT AREA OF MOVEMENT. Develop or obtain a representation of that area. 3. DEVELOP A LIST OF THE PROCESS STEPS, in sequence. The best way to do this is to develop or obtain a detailed flowchart of the process. 4. DRAW LINES ON THE LAYOUT showing every movement of the item as the process	Pros: • Can depict the flow of information, material, or people • Visual • Makes the wastes of motion and transportation very apparent • Useful tool when you want to look at waste in a department or for creating a more efficient layout Cons: • Time consuming	

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		lines showing all movements. The diagram graphically shows inefficiency—unnecessary movement. Shows movement within a process by people, materials, paperwork, or information. A floor plan of the work site is overlaid with the movement of the item of interest upon the floor plan, with the goal of identifying redundant motion and inefficiency. Used: • When the process being studied involves transportation or movement of people, materials, paper, or information • When trying to eliminate waste • For examining traffic flow patterns in clinics and hospital systems	proceeds from step to step. If the movement in a step follows the same path as the movement in a previous step, draw another line. Different colors or line types can be used to distinguish repeated pathways, different phases of the process, or different people or objects moving. 5. (Optional) IDENTIFY THE TIME REQUIRED for each movement. 6. ANALYZE THE DIAGRAM. Look for ways to eliminate or shorten movements. 1. Determine the item of interest that moves, e.g., people, paper, data, supplies, and materials. 2. Identify the realm within which the object moves. 3. Draw a floor plan of the realm. Computer software is very helpful for this task. 4. Develop a flowchart of the process for the object of interest that lists process steps in sequence. 5. Draw lines on the floor plan indicating every step that the object of interest takes in order to produce an		

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			output. 6. Analyze the workflow for overlap and inefficiency, e.g., excessive or unnecessary movement or motions that are repetitive. 7. Examine the floor plan or process flow for opportunities to improve the efficiency of the process. Resource: none Expertise: 1		

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Workflow Editor/Engine	Huser V, Rocha RA, James BC. Use of workflow technology tools to analyze medical data. 2006. Available at: http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=1647612. Accessed May 20, 2009. Enhydra. XPDL open source Java workflow. 2007. Available at: http://www.enhydra.org/workflow/index.html. Accessed May 20, 2009. Fox J, Black E, Chronokis I, et al. From guidelines to careflows: Modelling and supporting complex clinical processes. In: Teije A, Miksch S, Lucas P, editors. Computer-based medical guidelines and protocols: a primer and current trends. The Netherlands: IOS Press; 2008. p. 44-62.	Can be used to model medical processes and execute them on real coded medical data from large data repositories	Two input elements are required to receive the desired report about the variability of care. First, the user needs to specify the cohort of patients to be tested. Second, the user has to provide a defined scenario with valid links to clinical data elements currently available within the enterprise data warehouse (EDW). Resources: workflow editor/engine software Expertise: 3	Pro: • Can analyze large amounts of data • Results give insights into differences in workflows, data collection patterns and patient structure among different hospitals or providers • Free software Con: • Need simulation experience • Know java programming	Emanuele J, Koetter L. Workflow opportunities and challenges in health care. 2007. Available at: https://www.smed.com/healthcareit/hitpartner/Workflow Opportunities and Challenges in Healthcare white paper A9133-71250.pdf. Accessed April 20, 2009. Dadam P, Reichert M. Towards a new dimension in clinical information processing. In: Hasman A, Blobel B, Dudeck J, et al., editors. Medical Infobahn for Europe: Proceedings of MIE2000 and GMDS2000. The Netherlands: IOS Press; 2000. p. 295-301.

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Workload Profile Technique	Stanton N, Salmon P, Walker G, et al. Mental workload assessment method. Human factors methods: a practical guide for engineering and design. Great Britain: Ashgate; 2005. p. 301-64.	The workload profile technique is a recently developed multi-dimensional subjective mental workload assessment technique that is based upon the multiple resources model of attentional resources. The workload profile technique is used to elicit ratings of demand imposed by the task under analysis for the following eight mental workload (MWL) dimensions: • Perceptual/Central processing • Response selection and execution • Spatial processing • Verbal processing • Visual processing • Auditory processing • Manual output • Speech output Once the task(s) under analysis is completed, participants provide a rating between 0 (no demand) and 1 (maximum demand) for each of the MWL dimensions. The ratings for each task are then summed in order to determine an overall MWL rating for the tasks(s) under analysis. Used: • To elicit ratings of demand imposed by a task for several dimensions of mental workload (e.g. visual processing, verbal	1. DEFINE TASK(S) UNDER ANALYSIS. The first step in a workload profile analysis (aside from the process of gaining access to the required systems and personnel) is to define the tasks that are to be subjected to analysis. The types of tasks analyzed are dependent upon the focus of the analysis. 2. CONDUCT A HIERARCHICAL TASK ANALYSIS (HTA) FOR THE TASK(S) UNDER ANALYSIS. Once the task(s) under analysis are defined clearly, a HTA should be conducted for each task. This allows the analyst(s) and participants to understand the task(s) fully. 3. CREATE WORKLOAD PROFILE PRO—FORMA. Once it is clear which tasks are to be analyzed and which of those tasks are separate from one another, the workload profile pro-forma should be created. The left hand column contains those tasks that are to be assessed. The workload dimensions, as defined by Wickens	Pros: • The technique is based upon sound underpinning theory • Quick and easy to use, requiring minimal analyst training • As well as offering an overall task workload rating, the output also provides a workload rating for each of the eight workload dimensions • Multi-dimensional MWL assessment technique • As the technique is applied post-trial, it can be applied in real-world settings Cons: • It may be difficult for participants to rate workload on a scale of 0 to 1. A more sophisticated scale may be required in order to gain a more appropriate measure of workload. • The post-trial collection of MWL data has a number of associated disadvantages including 'forgetting' different portions of the task when workload was especially low • There is little evidence of the actual usage of the technique • Limited validation evidence associated with the technique • Participants require an understanding of MWL and multiple resource theory • The dimensions used by the technique may not be fully understood by participants with limited experience of	

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		processing, manual output, etc.)	multiple resource theory are listed across the page. 4. SELECTION OF PARTICIPANTS. Once the task(s) under analysis are defined, it may be useful to select the participants that are to be involved in the analysis. This may not always be necessary and it may suffice to simply select participants randomly on the day. However, if workload is being compared across rank or experience levels, then clearly effort is required to select appropriate participants. 5. BRIEF PARTICIPANTS. Before the task(s) under analysis are performed, all of the participants involved should be briefed regarding the purpose of the study, MWL, multiple resource theory and the workload profile technique. It is recommended that participants are given a workshop on MWL, MWL assessment and also multiple resource theory. The participants used should have a clear understanding of multiple resource theory, and of each	psychology and human factors	

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			dimension used in the workload profile technique. It may also be useful at this stage to take the participants through an example workload profile analysis. So that they understand how the technique works and what is required of them as participants. 6. CONDUCT THE PILOT RUN. Once the participant has a clear understanding of how the workload profile technique works and what is being measured, it is useful to perform a pilot run. The participant should perform a small task and then be instructed to complete a workload profile pro-forma. This allows participants to experience the technique in a task performance setting. Participants should be encouraged to ask questions during the pilot run in order to understand the technique and the experimental procedure fully. 7. TASK PERFORMANCE. Once the participants fully understand the workload profile		

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			techniques and the data collection procedure, they are free to undertake the task(s) under analysis as normal. 8. COMPLETION OF WORKLOAD PROFILE PRO-FORMA. Once the participant has completed the relevant task, they should provide ratings for the level of demand imposed by the task for each dimension. Participants should assign a rating between 0 (no demand) and 1 (maximum demand) for each MWL dimension. If there are any tasks requiring analysis left, the participant should then move onto the next task. 9. CALCULATE WORKLOAD RATINGS FOR EACH TASK. Once the participant has completed and rated all of the relevant tasks, the analyst(s) should calculate MWL ratings for each of the tasks under analysis. In order to do this, the individual workload dimension ratings for each task are summed in order to gain an overall workload rating for each task.		

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			Resources: none Expertise: 2		