Residency Training: Quality improvement projects in neurology residency and fellowship

Applying DMAIC methodology

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ABSTRACT

Objective: Teaching quality improvement (QI) is a priority for residency and fellowship training programs. However, many medical trainees have had little exposure to QI methods. The purpose of this study is to review a rigorous and simple QI methodology (define, measure, analyze, improve, and control [DMAIC]) and demonstrate its use in a fellow-driven QI project aimed at reducing the number of delayed and canceled muscle biopsies at our institution.

Methods: DMAIC was utilized. The project aim was to reduce the number of delayed muscle biopsies to 10% or less within 24 months. Baseline data were collected for 12 months. These data were analyzed to identify root causes for muscle biopsy delays and cancellations. Interventions were developed to address the most common root causes. Performance was then remeasured for 9 months.

Results: Baseline data were collected on 97 of 120 muscle biopsies during 2013. Twenty biopsies (20.6%) were delayed. The most common causes were scheduling too many tests on the same day and lack of fasting. Interventions aimed at patient education and biopsy scheduling were implemented. The effect was to reduce the number of delayed biopsies to 6.6% (6/91) over the next 9 months.

Conclusions: Familiarity with QI methodologies such as DMAIC is helpful to ensure valid results and conclusions. Utilizing DMAIC, we were able to implement simple changes and significantly reduce the number of delayed muscle biopsies at our institution. *Neurology*® 2015;85:e7-e10

GLOSSARY

DMAIC = design, measure, analyze, improve, and control; **IC** = informed consent; **QI** = quality improvement.

Teaching quality improvement (QI) is a priority for residency and fellowship training programs, partially stemming from mandates for formal QI education from organizations like the Accreditation Council for Graduate Medical Education.¹ Learning these competencies is of practical utility, as the American Board of Medical Specialties includes reporting on quality of care as part of their maintenance of certification program.² Within neurology, this may be via adherence to evidence-based quality guidelines published by the American Academy of Neurology or others.³

One of the most meaningful ways residents and fellows can participate in QI is to start a QI project. QI projects provide an opportunity for trainees to identify and correct gaps in the quality of care provided to patients, and gain a better understanding of how patient care relates to the health care system as a whole. QI projects may have the added benefit of improving the efficiency and quality of the academic teaching environment.⁴

The range of potential projects is broad because QI and patient safety span all areas of clinical practice. One way to conceptualize different areas of focus is to consider the 6 aims of improvement outlined by the Institute of Medicine.⁵ High-quality care should be safe (avoiding patient harm), effective (providing care based on scientific knowledge), patient-centered (providing care that respects patient preferences and values), timely (reducing harmful delays), efficient (avoiding waste), and equitable (care independent of personal characteristics like socioeconomic status).

As with medical research, QI should be conducted in a systematic and scientifically rigorous manner to reach valid conclusions. Several improvement methodologies have been adapted from other industries for use in health care. QI aims to improve patient care (the output) by changing something about the care provided (inputs). A major difference between QI and traditional medical research is that the intervention in QI is not predetermined. Instead, interventions are formulated after baseline data are collected and analyzed.

One QI methodology is design, measure, analyze, improve, and control (DMAIC).⁶ DMAIC provides a framework for approaching QI projects. The purpose of this article is to demonstrate how DMAIC can be applied by neurology trainees to identify and address quality gaps. Herein, we utilize DMAIC to reduce the percentage of delayed muscle biopsies at our institution and describe in detail each step of the methodology.

DMAIC Define. The first step is to identify a gap in quality and define the project aim. The project aim should be outlined in a Project Charter that includes aim statements identifying specific quantitative goals and a project timeline. It is important to identify stakeholders (persons involved in the process you hope to address or who will be impacted by changes you make) and seek their input.

Project example. Muscle biopsies require coordinated care among neurology, rheumatology, and surgery. The quality gap was that muscle biopsies were sometimes canceled or delayed due to avoidable errors. Our goal was to reduce the percentage of delayed biopsies to 10% or less within 24 months. We sought stakeholder input from colleagues in rheumatology and general surgery, who collaborated with us.

Measure. The second step is to determine which metrics to measure in order to capture errors and outcomes. These data serve as the baseline performance of the process. It is not practical to retrospectively obtain these data later, so it is critical to identify key measures at this stage. To avoid overlooking important measures it is useful to create a process map (figure, A), which is a graphical representation of steps within the process. Process maps inform the selection of measures and help identify points where measurements can be taken. There are 3 major types of measures. Outcome measures describe the overall performance of the process. Input measures are items put into the process (resources, finances, technology).

Process measures are similar to input measures, but are taken at critical points within the process, providing data about the performance of individual steps.

Project example. Our process map (figure, A) demonstrated that all patients had to attend an informed consent (IC) visit to obtain a biopsy, making the IC visit an ideal time to collect data. A data collection tool was created to be completed after each IC visit. The primary outcome measure was whether the muscle biopsy was delayed or canceled and why. Process measures included whether patients had fasted, held antithrombotic medications, and arranged for a companion to accompany them (a requirement of our institution's sedation policy).

Analyze. The analyze phase involves examining the collected data to identify root causes of the problem (root cause analysis). The analysis can be qualitative, quantitative, or both depending on the types of data collected. Although all causes are important, root causes accounting for the largest proportion of errors are the best targets for intervention, since they have the largest potential benefit. A fishbone diagram (also called a cause-and-effect diagram) displays sources of error, to help identify root causes of each problem (figure, B). A Pareto chart (figure, C) is an efficient way to analyze and display data, combining bar and line graphs to visualize the most important root causes. Causes of errors are listed on the x-axis and number of occurrences on the y-axis; the bars show the frequency of each cause, and the line graph is a cumulative tally of the frequency of errors.

Project example. Baseline data were collected on 97 of 120 muscle biopsies performed by general surgery in 2013. Twenty biopsies (20.6%) were delayed or canceled. Factors that contributed to muscle biopsy delays or cancellations were collected in a fishbone diagram (figure, B). A Pareto chart (figure, C) revealed that scheduling too many tests on the same day as the biopsy was the most common cause of delay, along with inadequate fasting.

Improve. The improve phase provides an opportunity to be creative and brainstorm ideas to address root causes. After producing multiple ideas, each should be evaluated for simplicity of implementation and potential impact. The best interventions are those with the highest yield for the lowest effort or cost. Simple interventions with low cost should be prioritized even if they have small impact, since the downside is negligible. Multiple solutions can be implemented together or sequentially. After each stage of implementation, performance should be re-measured (replicating the measure phase above), creating one or more plan-do-study-act cycles. Key measures are compared before and after implementation of improvement strategies to evaluate efficacy.

Project example. The first intervention was changing the timing of the IC visit to the afternoon. Surgical team members then knew the patient's schedule and

Figure Useful ways to display and analyze quality improvement data

(A) Process map for obtaining muscle biopsies, demonstrating the major steps and decision points in the process. (B) Fishbone diagram created to brainstorm possible causes of delayed muscle biopsies. (C) A Pareto chart showing the most common causes of delayed biopsies with their number of occurrences (bars). The cumulative total percentage of delayed biopsies is shown with the line graph. (D) Comparison of the percentage of delayed or canceled muscle biopsies before and after interventions. * $p < 0.05$. CA = clinical assistant; IC = informed consent visit; PA = physician assistant.

could plan the biopsy accordingly. This also provided time to educate patients about fasting and antithrombotic guidelines. At our institution, all patients receive an appointment guide with instructions for each test. The instructions for muscle biopsies were shortened and simplified. We created a patient handout titled "Planning for your muscle biopsy," which included reminders about fasting, antithrombotics, the sedation policy, and a checklist of how to prepare prior to the biopsy. Postintervention data were collected on 91 of 99 muscle biopsies performed by general surgery between January 1 and September 20, 2014. The effect of our interventions (figure, D) was to reduce the percentage of delayed or canceled biopsies from 20.6% (20/97) in the year prior to 6.6% (6/91; Student t test, $p < 0.05$).

Control. Once interventions are implemented and improvement is demonstrated, the goal is to maintain improvements over time. First, confirm that the main goals of the project (from the Project Charter) were addressed. Next, ensure that gains will be sustained by communicating results to stakeholders and outlining a plan for implementing changes as part of routine practice. It is useful to continue monitoring performance to confirm sustainability without creating new problems.

Project example. We continued to collect data beyond the initial improvement phase to demonstrate sustained improvement. Results were communicated to the neurology and rheumatology departments. Because of demonstrated success, our interventions have been adopted as routine care.

DISCUSSION Participating in a QI project during residency and fellowship has become a mandatory part of neurology training.¹ Many trainees have participated in clinical or basic science research but are less likely to have had exposure to QI methodologies. Thus, a QI project may initially seem foreign or daunting, since the approach and techniques are rooted in industrial theories centered on the elimination of error. DMAIC provides a useful framework for designing and implementing QI projects that ensures flexibility and quantification with the goal of producing sound and reproducible results.⁷ We have demonstrated how DMAIC can be used to improve the efficiency of obtaining muscle biopsies in a busy tertiary care practice.

AUTHOR CONTRIBUTIONS

C.D.K. contributed to the study design, data analysis, and drafting of the manuscript. M.L.W. contributed to the study design, data collection, and revision of the manuscript. D.J.v.B. contributed to the study design, data collection, and revision of the manuscript. F.C.E. contributed to the study concept and design and revision of the manuscript. A.N.L.H. contributed to the study concept and design, data analysis, and critical revision of the manuscript.

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