Using QI Methodology to Improve a Program’s QI Curriculum: An Educational Improvement Project
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INTRODUCTION
Quality improvement (QI) science is increasingly valued as a method for obtaining meaningful change. From the oath to “do no harm” to increasing requirements for QI skills and reliance on quality indicators for reimbursement, improving health care quality is a focus for practitioners, educators, and administrators. Yet, resident physician QI education reviews have shown variability in educational components, modalities, and duration.1,2 The 2016 Clinical Learning Environment Review (CLER) National Report1 found that despite significant progress, much work remains, especially when it comes to meaningful engagement. Most clinical learning environments had few residents with working knowledge of QI. In describing resident participation in QI projects, only a limited number of programs had residents “designing, managing, or analyzing the results of the activity.” Rather, implementing a hospital-wide initiative such as hand hygiene was common. The experiential learning necessary for professional development is lost when trainee involvement is only peripheral in QI work.4

Evaluation of educational efforts is also frequently discussed as a significant QI educators’ challenge.1,2,5,6 Previous reviews showed that most studies were before–after designs,2,7 and a few programs measured clinical impact.1,5 Additionally, in a 2021 realist synthesis, only 11% (n = 18) of the postgraduate medical education QI curricula were in pediatrics, and only 0.9% (n = 2) of the studies were designed as QI reports.8 In the most recent systematic review, authors found that although the number of published studies increased over time, the number reporting clinically relevant outcomes decreased despite an increase in studies requiring QI project completion.7 Although most curricula contain an experiential component,4 many programs continue to wrestle with simultaneously optimizing learning and project outcomes within complex health care settings.4

QI is a core competency.9,10 Education for physicians must be effective, emphasizing progressive learning goals over the length of residency and not just a few isolated learning experiences. Although the literature...
supporting QI education is growing, there are few comprehensive and longitudinal curricula demonstrating efficacy, patient impact, and future behaviors.\textsuperscript{1,2,3,7} Thus, curricula that achieve progressive learning goals may be more valuable to programs striving to improve QI education than descriptions of any particular curricular element.

This educational improvement study aimed to demonstrate a comprehensive, longitudinal curriculum that increased the percentage of residents reporting proficiency in practicing QI principles, scoring 90% or greater on the QI Knowledge Application Tool-Revised (QIKAT-R),\textsuperscript{11} and completing QI projects with at least 2 plan-do-study-act (PDSA) cycles to 90% within 5 years.

\section*{METHODS}

\subsection*{Context}

This single-center study occurred in a 226-bed children’s hospital within an independent academic medical center. The institution’s pediatric residency trains 13 categorical residents per year. Before this curriculum’s implementation, residents received no formalized QI training. Trainees were directed to identify an area for improvement within their work environment and work toward improvement as time allowed with no required level of completion. No faculty had been formally trained in QI at this curriculum’s initiation. The residency program currently includes 22 core faculty and 1.65 full-time-equivalent positions for education and scholarly activity, with 0.2 full-time-equivalent specifically dedicated to quality and safety education.

\subsection*{Needs Assessment}

The residency program did not have a QI curriculum at this study’s initiation. The authors completed a needs assessment, utilizing QI and patient safety (PS) content from the CLER Pathways to Excellence,\textsuperscript{12} American Board of Pediatrics general pediatrics content outline\textsuperscript{13} and Maintenance of Certification (MOC) part IV specifications,\textsuperscript{14} and Accreditation Council for Graduate Medical Education Common Program Requirements\textsuperscript{15} to generate themes. The authors then listed possible educational modalities and created corresponding measures for each item to track compliance and determine the curriculum’s success (Table 1, Supplemental Digital Content, \textit{http://links.lww.com/PQ9/A407}).

\subsection*{Rationale}

Improvement science offers several benefits to the evaluation and improvement of medical education, including focusing on the local educational setting, integrating a deep understanding of the local context, and testing multiple hypotheses and interventions over time.\textsuperscript{16} The Standards for Quality Improvement Reporting Excellence in Education standardized this approach in 2019.\textsuperscript{16}

\subsection*{Interventions}

The curriculum was first implemented during the 2014–2015 academic year and progressed through several iterations in response to feedback from trainees and process improvement efforts to achieve stated goals. The current curriculum is a 3-year, longitudinal progressive education (Table 1). Online QI modules through the Institute for Healthcare Improvement (IHI)\textsuperscript{17} and seven-to-ten 50-minute didactic workshops create foundational knowledge, followed by rapid personal improvement projects to put knowledge into practice during the intern year. The curriculum culminates in developing, leading, and completing multidisciplinary group QI projects during the second and third postgraduate years. In addition, each resident performs a root cause analysis (RCA) on an actual PS event involving a patient cared for by residents and presents their findings at a quarterly PS conference.

\subsection*{Study of the Interventions}

Scheduled resident feedback sessions provided detailed reflections as PDSA cycle-level data for each test of change. Curricular components were modified based on this feedback and progress on study measures.

\subsection*{Evolution of Interventions over Time}

Several curricular components evolved over time (Table 2). Initially, the curriculum director taught core concepts in lecture format. However, residents reported difficulty keeping up at subsequent lectures due to inconsistent attendance. The following year, we required completion of online IHI QI modules and created supplemental workshops to review and practice implementing QI tools. Workshops included sessions on error classification and system-based solutions for PS events; creating a detailed process map crossing several disciplines and containing multiple levels of decision branching; creating key driver and fishbone diagrams; and developing and interpreting run charts using gamification, which is the process of adding games or game-like elements to a task. Attendance at QI sessions improved when didactics changed to a single academic half-day schedule.

Initially, residents completed personal improvement projects in groups with a shared aim. This approach led to disparate knowledge and disjointed projects that did not achieve their aims. By the curriculum’s third year, residents completed personal improvement projects individually to consistently gain the necessary foundational knowledge.

We then turned our focus to resident QI projects. Unfortunately, the overall quality and success of projects were low. Residents were passionate about their project of choice but did not have the time to complete them independently. In addition, project faculty mentors lacked QI education and experience. To provide more mentoring and coaching by the quality curriculum director, rather than completing independent projects, each resident was required to participate in 1 of 3–4 group projects per class, reducing the total number of QI projects per year.
Subsequently, some residents expressed frustration from poor team dynamics and unfair distribution of tasks. In response, team members were asked to assign rotating resident QI project leads for each academic block. Responsibilities included meeting with the curriculum director for coaching and accountability, completing project tasks such as data collection and analysis, and communicating project updates to other project team members. This increased transparency such that less engaged residents may improve their participation. Open to all project team members, these meetings were frequently one-on-one due to busy resident schedules. The agenda consisted of project status within its timeline, results, barriers to success, and concrete “to do” tasks for that academic block. The curriculum director and resident QI lead discussed team dynamics and conflict resolution strategies when necessary. Informal handoff occurred between QI lead residents by email each block.

**Measures**

We borrowed the primary outcome measure from the Association of American Medical College’s aim in Teaching for Quality, the percentage of graduating residents self-reporting “proficiency in practicing QI principles in their everyday work.” Data were collected annually via a local survey in which positive answers included agree and strongly agree. We chose this as the primary outcome measure because one’s level of proficiency encompasses more than any single objective assessment, and the perception of one’s proficiency is an important driver of future QI endeavors. We balanced this self-reported proficiency with other objective measures of skill, including the percentage of graduating residents scoring >90% (24 out of 27 points) on the QIKAT-R, which tests residents’ ability to develop an aim statement, define measures, and propose system-based solutions. The QIKAT-R has been validated in previous studies.

The curriculum director administered and scored the QIKAT-R at the end of each academic year. A supplementary outcome measure was the percentage of resident QI projects that achieved improvement.

Process measures included attendance, participation in curricular components, and the percentage of resident QI projects completing at least 2 PDSA cycles. Since the educational activities of this curriculum occupied finite didactic time in the academic schedule, we tracked the
American Board of Pediatrics board passage rate as a balancing measure. The 3-year pass rate was chosen to counter expected year-to-year variability. In addition, we emailed an alumni survey in 2019 to 49 graduates who had completed the curriculum since 2014 and for whom we had current email addresses to ascertain sustainability of improvement and to understand the application of QI skills after graduation.

The authors evaluated several measures over time to assess resident behavior changes, including self-reporting the number of PS events reported and medical errors disclosed. Moreover, during the RCA investigation, the curricular director evaluated each resident's ability to elicit system-based causes and solutions. Additional measures extending beyond residents were impacts on faculty (number participating in resident QI initiatives and obtaining MOC part IV credit), the greater academic community (the number of conference presentations and publications), and patients (percentage of clinical projects achieving improvement in health care processes or patient-centered outcomes).

### Analysis

We collected annual prospective resident survey data, including the QIKAT-R, self-reported proficiency in practicing QI principles, the number of PS events reported and medical errors disclosed, beliefs regarding QI work, and satisfaction with the curriculum. Resident QI scholarly activity was tracked for quality and quantity. The Model for Improvement and sequential PDSA cycles were utilized, testing curricular changes for meaningful improvement in desired outcomes. Measures were plotted graphically by year. Due to the small number of data points, statistical process control charts were not used. Two-tailed Fisher exact tests and Mann-Whitney U tests determined whether significant differences were present between groups.

| Year  | Changes                                                                 | Outcomes                                                                 | Lessons Learned                                                                                                                                 |
|-------|------------------------------------------------------------------------|--------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|
| 2014  | Curriculum initiated with core lectures for foundational knowledge     | Poor attendance                                                          | Ensure all residents receive content for foundational knowledge                                                                         |
| 2015  | Foundational knowledge from core lectures replaced with online IHI QI modules | Difficulty understanding content of subsequent lectures by those who were absent | Assign IHI QI modules over shorter time frame                                                                                               |
| Late 2015 | IHI QI Modules supplemented with workshops to practice using tools and applying concepts | Residents felt the IHI QI modules were beneficial | Supplement modules with workshops                                                                                                           |
|       |                                                                        | Timing of completion of individual modules varied and was too spread out  | Continue workshops                                                                                                                        |
| 2016  | PGY1 rapid personal improvement projects were changed from group to individual projects to ensure all residents have a basic understanding of the components of a QI project | Workshops provided insight into local systems and interdisciplinary roles | Shift focus to improve experiential learning curricular components during late PGY1 and into PGY2                                           |
| 2017  | The program requirement was changed such that each resident must participate in 1 of 3–4 group projects in their PGY2–3 year to improve project rigor | Residents found the personal improvement project a good learning experience, but too time-consuming | Provide more guidance on achievable aims to avoid burdensome data collection                                                             |
| 2018  | Instituted regularly scheduled check-ins with each QI team to monitor progress over time | Residents reported difficulty choosing measures and results display        | Schedule sessions for feedback on project proposals before baseline data collection                                                           |
| 2019  | Added a resident QI project lead (self-selected) to each block rotation with clear expectations and responsibilities, including meeting with QI director for coaching and accountability | Residents expressed difficulty with team functioning while on different rotations | Shift focus to success of PGY2-3 group QI projects within the residency term                                                                  |
| 2020  | Tool developed to track meetings. Virtual option added. IHI modules completed during intern orientation, allowing earlier initiation of projects. Six faculty development QI sessions for PHM | Residents reported unfair distribution of work on some projects             | Ensure group projects are progressing each year                                                                                             |
|       |                                                                        | Residents reported difficulty choosing measures and results display        |                                                                                                                                |
|       |                                                                        | 2016 QIKAT-R scores increased from PGY1 to PGY2, but similar gains were not obtained in PGY3 |                                                                                                                                |
|       |                                                                        | 2017 QIKAT-R scores improved to goal for PGY3s                            |                                                                                                                                |
|       |                                                                        | Residents reported difficulty choosing measures and results display        |                                                                                                                                |
|       |                                                                        | Residents expressed difficulty with team functioning while on different rotations |                                                                                                                                |
|       |                                                                        | Residents reported unfair distribution of work on some projects            |                                                                                                                                |
|       |                                                                        | Residents reported unfair distribution of work on some projects            |                                                                                                                                |
|       |                                                                        | Residents reported unfair distribution of work on some projects            |                                                                                                                                |
|       |                                                                        | Residents reported unfair distribution of work on some projects            |                                                                                                                                |

FMEA, failure mode and effects analysis; PGY, postgraduate year; PHM, Pediatric Hospital Medicine.
Ethical Considerations
This study was a QI activity and not human subject research. Therefore, review and approval by the local institutional review board were not required.

RESULTS
The study aimed to increase the percentage of residents reporting proficiency in practicing QI principles, scoring >90% on the QIKAT-R, and completing QI projects with at least 2 PDSA cycles to 90% within 5 years. An average of 90% of residents completed the annual QIKAT-R and survey, ranging from 69% to 95% and remaining at >90% for the last 3 years. Within 4 years, and by the second graduating class receiving the entire longitudinal curriculum, residents reporting proficiency in practicing QI principles increased from 4 (44%) to 11 (100%) per year (Fig. 1). Those reporting proficiency before the curriculum implementation, 23% (n = 8), compared with those graduating in 2020, 92% (n = 12), was significant (P = 0.0001). Average graduating resident QIKAT-R scores increased from 0% before curriculum implementation to exceeding the goal of an average of 90% correct (P < 0.0001) (Fig. 2). Table 3 summarizes the results by Kirkpatrick model category, a widely accepted framework for evaluating educational interventions: (1) participation and reactions, (2) knowledge, skills, and attitudes, (3) behavioral change, and (4) change in organizational practice and demonstration of benefit to patients.

Although resident projects decreased from 10 in 2015 to 3–4 per year, project rigor and success improved. The proportion of resident QI projects completing at least 2 PDSA cycles increased from 30% (n = 3) in 2015 to 100% (n = 4) by 2018, P = 0.0005. In addition, the percentage of projects achieving improvement was 40% (n = 4) in 2015 and reached 100% (n = 3) by 2019, P = 0.002. Table 4 demonstrates curricular impact over time.

Notably, patients were also positively impacted. Sixty percent (n = 3) of clinical QI projects that measured patient-centered outcomes achieved improvement, and 69% (n = 11) of clinical QI projects improved clinical healthcare processes (Table 2, Supplemental Digital Content, http://links.lww.com/PQ9/A407). The success of resident education in QI science was not at the expense

![Residents Reporting Proficiency in Practicing QI Principles](image)

**Fig. 1.** Percentage of residents reporting proficiency in practicing QI principles in the context of their everyday work. The proportion of residents in the class of 2015 compared with the class of 2020 who reported proficiency was significant, P = 0.046, by Fisher exact testing. Note: posttests were administered at the end of each academic year.
of other core didactics, as represented by our balancing measure, the 3-year average general pediatrics certifying exam passage rate for first-time test takers: 82% (n = 29) for 2012–2014 and 97% (n = 38) for 2018–2020. Additionally, from 2015 to 2020, this curriculum added 31 QI projects to our local healthcare system, 1 journal publication, 33 presentations at medical conferences, and MOC part IV credit for 19 faculty and 40 residents. In addition, this curriculum provided 22 faculty with experiences as QI team members, learning the application of methodology and tools alongside residents.

PS reporting of medical errors by graduating residents remained the same at an average of 2–5 reports per resident in 2017 when these data were first collected and again in 2020. However, residents disclosing medical errors to patients increased with an average of 1 disclosure per graduating resident in 2017 compared with 2–4 disclosures in 2020. Within the last graduating class, all residents submitted multiple PS reports and disclosed an error at least once, with 92% (n = 12) disclosing errors more than once. Residents also increasingly identified system-based solutions during RCA investigations [0% in 2017; 100% (n = 13) in 2020]. Ninety-four percent (n = 32) of residents receiving the full 3-year curriculum were satisfied with the QI training they received during residency, and none were dissatisfied. Twelve alumni reported completing 14 additional QI projects, and 1 graduate commented that the curriculum “sparked an interest, and I have since completed a fellowship in QI.” Another expressed having “much more knowledge of QI compared with my cofellows.”

**DISCUSSION**

This study developed a comprehensive, longitudinal QI curriculum that effectively established resident knowledge, comfort, and QI skills through careful measurement and iterative change, but importantly also benefited patients and impacted resident behaviors. The specific aims were met, resulting in a significant increase in the percentage of residents reporting proficiency in practicing QI principles, scoring >90% on the QIKAT-R, and completing QI projects with >2 PDSA cycles to 90%.

The percentage of graduating residents reporting proficiency in practicing QI principles was not sustained at 100%, dropping to 92% the following 2 years. This decrease was possibly due to common cause variation. However, we theorized that poor distribution of participation within the group QI projects contributed. To address this, we adjusted the workflow among group QI project members, designating each resident as project lead for at least 3 educational blocks per year. We have not yet fully evaluated this adjustment.

The change in the number of resident QI projects from 10 to 3–4 per year may have had the greatest impact on the rigor and success of projects—fewer projects allowed for more frequent coaching from the curriculum director. In addition, the group rather than individual projects allowed for shared responsibilities during busy clinical rotations. Therefore, we recommend reducing the number of QI projects per year for programs with limited QI-trained faculty. This recommendation is consistent with findings by Brown et al that team-based, heavily mentored projects with frequent meetings are associated
with successful curricula. While group projects have the potential for workload maldistribution and making individual resident assessment difficult, scheduled meetings with assigned resident leads allow for individual knowledge and participation evaluation.

Our QI curriculum shares elements associated with successful curricula, including longitudinal curricula with experiential, project-based learning with topics screened to ensure appropriate scope and alignment with health system priorities; frequent meetings to maintain momentum; clear expectations and deliverables; and academic incentives for faculty. Also, our study demonstrates a successful curriculum despite lacking protected time for projects and easily accessible data.

This educational improvement study also offers a method by which curriculum development can be aided by QI science, creating successful content and measuring and achieving specific outcomes over time. The next steps in this study will involve targeting QI skills with poor performance and increasing faculty development in QI science.

### Strengths
Strengths of the curriculum include the continuous analysis and modification of the content, utilization of free educational resources, and robust experiential learning opportunities. In addition, there were many facilitators to our success. Most importantly, there has been strong programmatic support, dedicating time within the didactic schedule, and funding for the director role. This role provided time to oversee assignments, facilitate workshops, mentor and coach projects, and evaluate the curriculum. Results may be generalizable to similarly sized programs with leadership buy-in and funding for the director position. Training for the curriculum director role was self-directed and did not require additional graduate degrees.

| Kirkpatrick Model of Evaluation | QI Curriculum Evaluation Metrics | Pre/Early Curriculum | Post curriculum | P |
|---------------------------------|---------------------------------|----------------------|-----------------|---|
| 1 Participation                 | % Attendance/participation in curricular components of IHI modules; workshops on process maps, driver and fishbone diagrams, medical error classification and system-based solutions, run chart and statistical process control chart; personal improvement projects; RCA performance; group QI project leadership role. | n/a | 100% (n = 13) | — |
| Satisfaction                    | % Satisfied with curriculum | n/a | 96% (n = 50) | — |
| 2 Attitudes                     | % Reporting proficiency in QI skills | 23% (n = 9) | 92% (n = 12) | 0.0001 |
|                                | % Perceiving QI as essential to providing good patient care | 89% (n = 28) | 100% (n = 13) | 0.17 |
| Knowledge                       | % Scoring ≥90% on QIKAT-R | 0% (n = 0) | 85% (n = 11) | <0.00001 |
| Skills                          | % QI projects completing ≥2 PDSA cycles | 30% (n = 3) | 100% (n = 3) | 0.0005 |
|                                | % Residents completing RCAs on PS events | 0% (n = 0) | 100% (n = 13) | <0.00001 |
| 3 Behavioral change            | Average no. PS reports | 2–5 per resident | 2–5 per resident | — |
|                                | Average no. medical errors disclosed to patients | 1 per resident | 2–4 per resident | — |
|                                | % Residents utilizing system-based solutions during RCAs | 0% (n = 0) | 100% (n = 13) | 0.001 |
|                                | No future QI projects by residents after graduation | unknown | 14% | — |
| 4 Change in organizational practice | % QI projects achieving success | 40% (n = 4) | 100% (n = 3) | 0.002 |
|                                | % Clinical QI projects achieving improvement in health care processes | 10% (n = 1) | 69% (n = 11) | 0.001 |
|                                | No. QI projects completed in the local healthcare system | 10 | 31 | — |
|                                | No. faculty participating in resident QI initiatives and obtaining MOC part IV credit | 0 | 32 | — |
|                                | No. conference presentations at medical conferences | 10 | 33 | — |
|                                | Demonstration of benefit to patients | 3-y average general pediatrics certifying exam passage rate for first-time test takers | 82% (n = 29) | 97% (n = 38) | 0.11 |
| 4 Change in organizational practice | % of clinical QI projects achieving improvement in patient-centered clinical outcomes | 10% (n = 1) | 60% (n = 3) | 0.036 |
|                                | No future QI projects by residents after graduation | unknown | 14% | — |
| 4 Change in organizational practice | % of clinical QI projects achieving improvement in patient-centered clinical outcomes | 10% (n = 1) | 60% (n = 3) | 0.036 |
|                                | No future QI projects by residents after graduation | unknown | 14% | — |

Where possible, metrics compare precurriculum data with the most recent postcurriculum (2020) data. However, certain data were not collected before curriculum implementation. In these instances, we present the earliest data collected.

1IHI modules; workshops on process maps, driver and fishbone diagrams, medical error classification and system-based solutions, run chart and statistical process control chart; personal improvement projects; RCA performance; group QI project leadership role.

2Essential to: patient outcomes; personal performance; safe, effective, efficient, equitable, time-sensitive, and patient-centered care.

3Data first collected at the end of the 2015 academic year.

4Data were first collected at the end of the 2017 academic year. All results are from the graduating class unless otherwise specified.

5Data were first collected at the end of the 2017 academic year. All results are from the graduating class unless otherwise specified.

6Data were first collected at the end of the 2015 academic year.

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