

Implementation of a Quality and Patient Safety Curriculum for Pathology Residency Training

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Abstract

Quality and Patient Safety education for resident physicians is necessary to prepare them for independent practice and to meet accreditation requirements. Integrating such education into the residents' routine work can provide them with valuable practical experience, while advancing the institution's quality priorities. We committed to Quality and Patient Safety education for our pathology residents but found no published program that met their specific needs. To fill this gap in pathology residency education, we designed and implemented a new curriculum that spans the 4-year duration of residency training. Curriculum content was drawn from the pathology milestones, and educational strategies were based on the principles of adult learning. The curriculum was implemented in the 2018 to 19 academic year, and residents were assessed before and after their participation. The residents engaged in several Quality and Patient Safety activities and projects under faculty supervision, and improved their scores on objective assessments (Quality and Patient Safety quiz and in-service examination). Implementation was facilitated by a Quality and Patient Safety chief resident, and the recruitment of faculty with demonstrated Quality and Patient Safety interest. Our comprehensive Quality and Patient Safety curriculum is feasible to implement and can help pathology residents develop the knowledge and skills needed to lead quality initiatives. We believe that the curriculum framework is readily adaptable to other residency programs.

Keywords

quality improvement, patient safety, pathology, curriculum, medical education

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Introduction

Led by the release of *To Err is Human: Building a Safer Health System* by the Institute of Medicine, nearly 20 years ago, the health care industry has put great effort into optimizing Quality and Patient Safety (QPS).¹ As resident physicians are often frontline providers of health care, it is essential to integrate them into organizational quality initiatives. Quality and Patient Safety education for resident physicians was addressed by the Accreditation Council for Graduate Medical Education (ACGME) as far back as the 1999 Outcome Project² and is mandated by the present Common Program Requirements.³ A recent review of over 9000 residency and fellowship programs reported an overall improvement in organizational QPS efforts but identified a shortfall in the integration of trainees in these efforts.⁴

In pathology, serious interest in QPS was prompted by a 1987 newspaper article about "Pap mills," high-volume cytology laboratories that prioritized quantity over quality.⁵ This adverse publicity resulted in the quality requirements specified

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by the Clinical Laboratory Improvement Amendments (CLIA) of 1988,⁶ giving pathology departments a head start in implementing QPS. However, the associated skills and methods have generally not been formally taught to residents. This education gap has significant implications for their future independent practice, where they will be expected to lead quality initiatives.

In 2014, we started work on developing a QPS program for our pathology residents. A literature search at the time yielded descriptions of QPS education programs for residents in several clinical disciplines. The programs were typically designed around didactic teaching and QPS projects. Most programs were offered as short rotations (weeks to months), and there were a few longer programs integrated through a year or more of residency training.⁷⁻¹³ However, no program addressed the scope of pathology practice, that is, the strict regulatory and accreditation requirements that must be satisfied, the highly process-driven nature of laboratory operations, and a practice environment in which vital information is often communicated without face-to-face contact. In this article, we describe the creation and implementation of a comprehensive QPS curriculum, intended specifically for pathology residents. We note that a patient safety curriculum for Anatomic Pathology residents was published while we were developing and implementing our curriculum.¹⁴

Materials and Methods

Setting

Our pathology residency program is based at a large tertiary care center. The program has 83 faculty members and admits 7 residents each year. The clinical material available for resident education is obtained from over 18.5 million laboratory tests and procedures each year, including approximately 185 000 surgical pathology accessions and 250 autopsy cases.

Description of the Innovation

Curriculum design. We used the 6 steps of Problem Identification, Needs Assessment, Goals and Objectives, Educational Strategies, Implementation, and Program Evaluation.¹⁵ Throughout the process, including the Implementation phase, we actively solicited input from the principal stakeholders, that is, the residents, the residency Program Director, and selected members of departmental leadership, and modified the curriculum in response to their needs and expectations.

We identified 4 major topics for the curriculum, based on the ACGME Pathology Milestones in effect at the time: Hand-off Communication, Error Management, Laboratory Accreditation and Process Improvement (HELP).¹⁶ For each topic, we developed goals and specific objectives based on the residents' routine work, and educational strategies based on the principles of adult learning, that is, self-directed learning, active learning through work-related activities, problem-centered learning, learning dependent on social context, and reflective learning (Table 1).^{17,18}

The self-study components of the curriculum were based on online courses from the Institute for Healthcare Improvement (IHI) Open School¹⁹ and the College of American Pathologists (CAP), supplemented with pertinent journal articles²⁰⁻²⁸ and website links. Sets of assessment questions were developed to guide self-directed reading and to facilitate discussion in the faculty-led group sessions.

To identify any unanticipated, major practical difficulties, portions of the curriculum were field-tested on 2 senior residents (postgraduate year [PGY] 3-4). Their feedback on the quantity and quality of the content was positive; however, the task of implementing the curriculum for the entire program required further planning and creativity.

Curriculum delivery. Learning modules were created in our institution's online residency management system (MedHub). The modules contained introductory components for self-directed learning, and faculty-led group sessions that included interactive discussion, video simulations, role-play, feedback, and reflection. In addition, residents participated in real-life QPS activities, namely, laboratory inspections, committee service and QPS projects. Completion of the modules was tracked automatically online for some components, and via the portfolio system for the remainder.

Curriculum implementation. We implemented the curriculum in the 2018 to 2019 academic year. A QPS chief resident²⁹ was selected from among the PGY3 and PGY4 residents, with responsibility for planning and tracking curriculum activities, and to represent the residents on departmental and institutional QPS committees.

The Hand-off Communication modules were administered every year, given the critical nature of the topic for the residents' daily work. The other modules were administered on an approximately 2-year cycle. Thus, residents were engaged in QPS activities throughout their 4-year program and had the opportunity to repeat faculty-led sessions and reinforce learning.

Each year, 3 QPS projects were selected by the program director from among proposals submitted by the faculty. This selection was made in January, and every resident in the program was assigned to a project. The project teams had several months to work on their assignments, after which the results were reported at departmental Grand Rounds in December, and submitted for presentation at the institution's annual Patient Safety Day event.

Curriculum assessment. A 42-question multiple-choice quiz based on the curriculum content was designed by the program director and QPS chief resident. This quiz was administered to the residents before starting the curriculum and again, after approximately 10 months. The question set is provided as Supplementary File 1.

De-identified (aggregate average) results of the Laboratory Administration category of the Pathology Resident In-Service

Table 1. Curriculum Content, Format, and Attendance Requirements.

Module	Format	Educational content	PGY1	PGY2	PGY3	PGY4
Hand-off Communication	Self-study	- IHI course:¹⁹ Teamwork and Communication - Residency program's Transition of Care Policy - Patterson et al. <i>Int J Qual Health Care.</i> 2004;16:125-32.²⁰	x	x	x	x
	Faculty-led simulation, 60 min	- Complete self-assessment questions - Videotaped hand-off simulations - Supervised practice of hand-offs, using the SBAR (situation, background, assessment, recommendation) model.	x	x	x	x
Error Management 1: Patient Safety and the Laboratory	Self-study	- Vincent et al. <i>BMJ</i> 1998; 316:1154-7.²¹ - Laposata and Cohen. <i>Arch Pathol Lab Med.</i> 2016;140:505-7.²² - Dintzis et al. <i>Arch Pathol Lab Med.</i> 2017;141:841-845.²³ - IHI courses:¹⁹ Introduction to Patient Safety and From Error to Harm - Serious reportable events: http://www.qualityforum.org/Topics/SREs/Serious_Reportable_Events.aspx - Training for the institutional incident reporting system	x	x		
	Faculty-led discussion group, 30 min	- Complete self-assessment questions - Review of self-assessment questions - Discussion of the role of pathologists in preventing and managing errors	x	x		
Error Management 2: Root Cause Analysis	Self-study	- IHI course:¹⁹ Root Cause Analysis - CAP course: Root Cause Analysis - Complete self-assessment questions			x	x
	Faculty-led simulation, 60 min	Simulated root cause analysis of a recent laboratory error			x	x
Laboratory Accreditation 1: Basics of Accreditation	Self-study	- Listing of accreditations and licenses for institutional laboratories - Hamlin. <i>Arch Pathol Lab Med.</i> 1999; 123:465-7.²⁴ - Peter, et al. <i>Am J Clin Pathol.</i> 2010; 134:550-5.²⁵ - Tzankov and Tornillo. <i>Pathobiology.</i> 2017; 84:121-9.²⁶ - CLIA regulations at www.ecfr.gov. Title 42, part 493, subparts A and M (General Provisions and Personnel for Non-waived Testing) PGY2 https://www.jointcommission.org/accreditation-and-certification/health-care-settings/laboratory-services/	x	x		
	Faculty-led discussion group, 30 min	- Complete self-assessment questions - Review of self-assessment questions - Discussion regarding impact of laboratory accreditation in the quality of patient care	x	x		
Laboratory Accreditation 2: Proficiency Testing	Self-study	- Laboratory proficiency testing slide deck (institutional resource) - Astles, et al. <i>MLO.</i> 2013;45:8-15.²⁷ - CLIA regulations at www.ecfr.gov. Title 42, part 493, subpart H (Proficiency testing) - Complete self-assessment	x	x		
	Faculty-led simulation, 60 min	- Review of self-assessment questions - Mock proficiency testing review	x	x		
Laboratory Accreditation module 3: Laboratory Inspections	Self-study	- CAP team member inspection training: https://www.cap.org/laboratory-improvement/accreditation/inspector-training - CAP courses: ISO 15189 and QMS Implementation Roadmap			x	x
	Faculty-supervised experience	- Participation in a real or mock laboratory inspection - Complete self-assessment of experience			x	x

(continued)

Table 1. (continued)

Module	Format	Educational content	PGY1	PGY2	PGY3	PGY4
Process Improvement 1: Principles of Quality Improvement	Self-study	IHI courses:¹⁹ Introduction to Health Care Improvement and How to Improve with the Model for Improvement	x	x		
Process Improvement 2: Implementing Quality improvement	Self-study	IHI courses:¹⁹ Testing and Measuring Changes with PDSA Cycles, Interpreting Data: Run Charts, Control Charts and Other Measurement Tools, and Leading Quality Improvement		x	x	
	Faculty-supervised experience	- Service on a quality committee for at least one quarter during residency - Complete self-assessment of experience		x	x	x
Process Improvement 3: Test Utilization and the Laboratory	Self-Study	- Strategies for appropriate test utilization whitepaper by Dr. Gary Procop (https://clevelandcliniclabs.com/wp-content/assets/pdfs/publications/2014-test-utilization.pdf) - Procop GW, Weathers AL, Reddy AJ. Operational Aspects of a Clinical Decision Support Program. Clin Lab Med 2019;39:215-229.²⁸			x	x
	Faculty-supervised simulation, 60 min	Test utilization simulation of common laboratory scenarios			x	x

Abbreviations: CAP, College of American Pathologists; IHI, Institute for Healthcare Improvement; PGY, postgraduate year.

Table 2. Mean Scores (%) on the QPS Quiz Before Implementing the QPS Curriculum and Approximately 10 Months After Curriculum Implementation.

PGY	Preimplementation	Postimplementation ^a	Difference
4	54.7 (n = 7)	65.0 (n = 6)	+10.3
3	62.4 (n = 7)	66.3 (n = 7)	+3.9
2	54.5 (n = 6)	68.0 (n = 6)	+13.5
1	60.0 (n = 8)	72.0 (n = 7)	+13.0

Abbreviations: PGY, postgraduate year; QPS, Quality and Patient Safety.

^aTwo residents did not complete the postimplementation quiz as they had left the program.

Exam (RISE; ASCP) were reviewed for the year before and the 2 years after curriculum implementation.

A 4-question survey was developed by the program director to gauge the residents' ease with QPS topics. This survey was administered before starting the curriculum and again, after the first year. The survey questions are provided as Supplementary File 2.

We were advised by the institutional review board that our curriculum assessment was exempt from review, as it was a part of the evaluation of an educational program.

Results

Outcomes Measured

After a year of participating in the QPS curriculum, there was an increase in mean scores on the QPS quiz (Table 2) and the RISE Laboratory Administration section (Table 3) for every PGY level. Improved RISE scores were also noted for the resident cohorts progressing from 1 PGY level to the next (Figure 1).

The residents' QPS projects included topics in blood management, laboratory reference ranges, handling of urgent samples, callback of critical results, and frozen section sampling, all of which were closely aligned with the department's quality and operational priorities. In the two years since implementation of the curriculum, every PGY2-4 resident has completed one project each year. All of the projects were presented internally, and one secured the best poster award at the 2019 institutional Patient Safety Day event. In addition, all of the projects were presented externally, including 2 at national conferences.

Quality committees on which the residents have served include 11 intradepartmental and 2 cross-departmental committees. The average length of service was 3 months.

The laboratory accreditation inspections conducted by the residents include internal midterm inspections and one inspection of an external laboratory.

Cost

The design of the QPS curriculum was funded through an institutional Medical Education Fellowship awarded to one of the authors. The cost of creating the QPS chief resident position included support for attending a national QPS meeting (up to USD 1750, up to 5 meeting days) and the CAP Laboratory Director online course (cost USD 180).

The time commitment for coordinating QPS activities was estimated at approximately 12 hours a month. The QPS chief resident was not provided with protected time for this responsibility.

There was no additional direct cost for curriculum implementation; the online courses (IHI, CAP) had already been purchased

Table 3. Aggregate Average RISE Laboratory Accreditation Section Scores (Percentile) Before and After Implementing the QPS Curriculum.

PGY	2018 (preimplementation)	2019 (1 year postimplementation)	2020 (2 years postimplementation)
Overall	55	80	70
4	35	90	60
3	60	85	75
2	65	90	80
1	50	80	85

Abbreviations: PGY, postgraduate year; QPS, Quality and Patient Safety; RISE, Resident In-Service Exam.

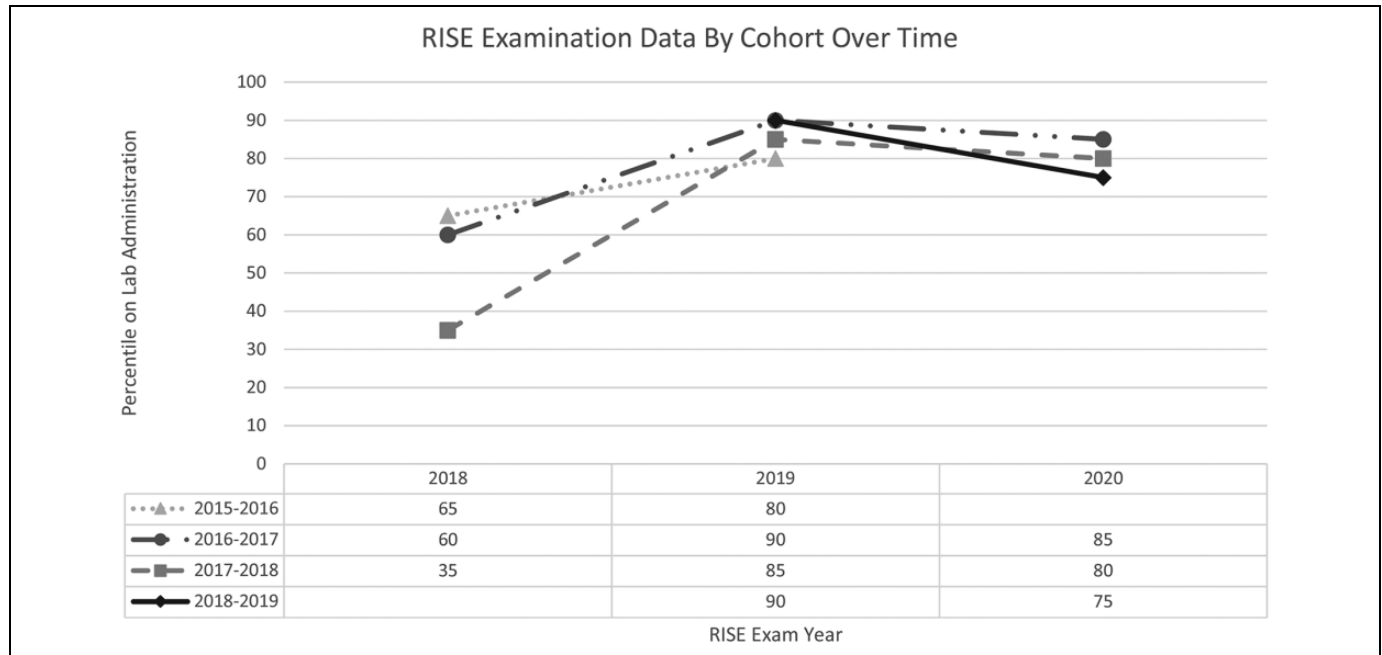


Figure 1. Aggregate average RISE laboratory accreditation section scores (percentile) by PGY cohort before (RISE year 2018) and after (RISE years 2019 and 2020) implementing the QPS curriculum. The label for each cohort indicates the first year of residency. PGY indicates postgraduate year; QPS, Quality and Patient Safety; RISE, Resident In-Service Exam.

for other educational use, and curriculum delivery and tracking were achieved through existing systems.

Feasibility

The self-directed components of the learning modules allowed the residents significant flexibility in time management. However, organizing the faculty-led group sessions was challenged by time constraints and faculty participation. To address the time constraints, we scheduled faculty-led sessions during existing slots in the residents' regular lecture calendar. We used only four slots over the entire year by simultaneously running the sessions for PGY1-2 (4 meetings) and PGY3-4 (3 meetings). To encourage faculty participation, the program director invited key faculty members with high engagement in QPS and residency education (eg, laboratory directors, section heads). Four such faculty members led the group sessions for review of self-assessment questions, and for the simulation sessions on hand-offs, root cause analysis, proficiency testing and test utilization.

The QPS chief resident had an invaluable role in facilitating delivery of the curriculum and overcoming day-to-day implementation challenges. His involvement included orienting new residents in QPS at orientation, scheduling group sessions, assisting the faculty to develop content for group sessions, updating curriculum content (eg, course links), coordinating resident assignments for committee service and laboratory inspections, monitoring resident completion of assigned modules, and acting as a liaison for quality and patient safety issues involving the department.

As the process of selecting QPS projects is repeated every year, every resident may expect to participate in at least 3 QPS projects, building significant QPS experience and expertise over the duration of residency.

Acceptance

Most residents (60%) felt that the curriculum provided the right amount of content. They reported an increased ease with QPS issues after the first year of the curriculum, with 60% of

residents indicating that they felt “somewhat comfortable” or “very comfortable,” compared to 39% before curriculum implementation. Significantly, one-third of the residents reported QPS projects as an effective educational strategy, compared to only 6% before curriculum implementation.

Discussions at the monthly pathology education committee meetings indicate that the residents have come to value the unique experiences of practical QPS activities that form the backbone of the QPS curriculum. Their acceptance of the QPS curriculum has been likely boosted by the ready affirmation of their constructive feedback, which has been channeled into curriculum improvements.

Discussion

We report the successful implementation of a comprehensive new QPS curriculum intended specifically for pathology residents and integrated into the entire 4-year duration of their training. As the practical elements of the curriculum, including quality projects, quality committees, and inspections, are integral and ongoing parts of pathology operations, the residents’ participation in these activities have required little more than coordination of scheduling by the QPS chief resident. The residents have shown sustained objective improvement in QPS knowledge and have successfully completed several QPS projects in support of the department’s quality agenda. Group participation in QPS projects has encouraged the development of mentoring relationships between junior and senior residents, and promoted the equitable distribution of workload.

After our 2-year implementation experience, we expect the additional effort of maintaining the curriculum to be limited to calendar coordination and minor content updates. However, we plan to continue using objective assessment and subjective feedback to ensure that it meets the residents’ needs for QPS education.

While the QPS curriculum was developed specifically for a pathology residency program, our experience with its design and implementation is limited to a single institution, and only short-term outcome data are available. The definitive measure of our curriculum, the reported experience of our graduates entering practice and dealing with real-life quality initiatives, is awaited. Nevertheless, our QPS curriculum offers a framework that other residency programs—pathology or non-pathology—may adapt to suit their own context. Potential users of this curriculum may elaborate further on its elements, by creating tools to evaluate the quality of learning and developing a formal faculty development program. We suggest, however, that implementation of the curriculum not be delayed until every detail is in place; the educational value of an imperfect process that must be negotiated through trial and error should not be underestimated, especially in the context of learning QPS.

In conclusion, we believe that the new QPS curriculum is helping our residents to gain the knowledge, skills, and experience needed to supervise a laboratory and contribute effectively to quality and practice improvements in pathology. Integrating the curriculum into routine practice has ensured that

the residents are actively engaged in departmental quality priorities. The curriculum can be feasibly implemented within the time and resource constraints of a busy pathology residency program.

Authors’ Note

This work was presented in poster form at the 2015 and 2020 ASCP Annual Meetings:

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Supplemental Material

Supplemental material for this article is available online.

References

1. Institute of Medicine US Committee on Quality of Health Care in America. In: Kohn LT, Corrigan JM, Donaldson MS, eds. *To Err is Human: Building a Safer Health System*. National Academies Press; 2000.
2. Swing SR. The ACGME outcome project: retrospective and prospective. *Med Teach*. 2007;29(7):648-654.
3. Accreditation Council for Graduate Medical Education. Common program requirements, effective. Published July 1, 2020. Accessed February 18, 2021. <https://www.acgme.org/Portals/0/PFAssets/ProgramRequirements/CPRResidency2020.pdf>
4. CLER Evaluation Committee. In: Co JPT, Bagian JP, Weiss KB, eds. The overarching themes from the CLER national report of findings 2018. *J Grad Med Educ*. 2018;10(4 suppl):19-24.
5. Bogdanich W. Lax laboratories: the pap test misses much cervical cancer through labs’ errors—cut-rate “Pap Mills” process slides using screeners with incentives to rush—misplaced sense of

- security? Eastern edition; New York, NY. *Wall Street Journal*. Nov 2, 1987:1.
6. Davey DD, Austin RM, Birdsong G, Zaleski S. The impact of the clinical laboratory improvement amendments of 1988 on cytopathology practice: a 25th anniversary review. *J Am Soc Cytopathol*. 2014;3(4):188-198.
 7. Voss JD, May NB, Schorling JB, et al. Changing conversations: teaching safety and quality in residency training. *Acad Med*. 2008; 83(11):1080-1087.
 8. Kim CS, Lukela MP, Parekh VI, et al. Teaching internal medicine residents quality improvement and patient safety: a lean thinking approach. *Am J Med Qual*. 2010;25(3):211-217.
 9. Arbuckle MR, Weinberg M, Cabaniss DL, et al. Training psychiatry residents in quality improvement: an integrated, year-long curriculum. *Acad Psychiatry*. 2013;37(1):42-45.
 10. Tudiver F, Click IA, Ward P, Basden JA. Evaluation of a quality improvement curriculum for family medicine residents. *Fam Med*. 2013;45(1):19-25.
 11. Hall Barber KH, Schultz K, Scott A, Pollock E, Kotecha J, Martin D. Teaching quality improvement in graduate medical education: an experiential and team-based approach to the acquisition of quality improvement competencies. *Acad Med*. 2015;90(10): 1363-1367.
 12. Simasek M, Ballard SL, Phelps P, et al. Meeting resident scholarly activity requirements through a longitudinal quality improvement curriculum. *J Grad Med Educ*. 2015;7(1):86-90.
 13. Pensa M, Frew P, Gelmon SB. Integrating improvement learning into a family medicine residency curriculum. *Fam Med*. 2013; 45(6):409-416.
 14. Samulski TD, Montone K, LiVolsi V, Patel K, Baloch Z. Patient safety curriculum for anatomic pathology trainees: recommendations based on institutional experience. *Adv Anat Pathol*. 2016; 23(2):112-117.
 15. Thomas PA, Kern DE, Hughes MT, Chen BY. *Curriculum Development for Medical Education. A Six-step Approach*. 3rd ed. The Johns Hopkins University Press; 2016.
 16. Naritoku WY, Alexander CB, Bennett BD, et al. The pathology milestones and the next accreditation system. *Arch Pathol Lab Med*. 2014;138(3):307-315.
 17. Kaufman DM. Applying educational theory in practice. *BMJ*. 2003;326(7382):213-216.
 18. Green ML, Ellis PJ. Impact of an evidence-based medicine curriculum based on adult learning theory. *J Gen Intern Med*. 1997;12(12):742-750.
 19. Institute for Healthcare Improvement Open School. Modified October 5, 2020. Accessed February 18, 2021. <http://www.ihio.org/education/ihioopenschool/Pages/default.aspx>
 20. Patterson ES, Roth EM, Woods DD, Chow R, Gomes JO. Handoff strategies in settings with high consequences for failure: lessons for health care operations. *Int J Qual Health Care*. 2004;16(2): 125-132.
 21. Vincent C, Taylor-Adams S, Stanhope N. Framework for analyzing risk and safety in clinical medicine. *BMJ*. 1998;316(7138): 1154-1157.
 22. Laposata M, Cohen MB. Its our turn: implications for pathology from the institute of medicines report on diagnostic error. *Arch Pathol Lab Med*. 2016;140(6):505-507.
 23. Dintzis SM, Clennon EK, Prouty CD, Reich LM, Elmore JG, Gallagher TH. Pathologists' perspectives on disclosing harmful pathology error. *Arch Pathol Lab Med*. 2017;141(6):841-845.
 24. Hamlin WB. Requirements for accreditation by the college of American Pathologists Laboratory Accreditation Program. *Arch Pathol Lab Med*. 1999;123(6):465-467.
 25. Peter TF, Rots PD, Blair DH, Khine AA, Freeman RR, Murtagh MM. Impact of laboratory accreditation on patient care and the health system. *Am J Clin Pathol*. 2010;134(4):550-555.
 26. Tzankov A, Tornillo L. Hands-on experience: accreditation of pathology laboratories according to ISO 15189. *Pathobiology*. 2017;84(3):121-129.
 27. Astles J, Stang H, Alspach T, Mitchell G, Gagnon M, Bosse D. CLIA requirements for proficiency testing: the basics for laboratory professionals. *Med Lab Obs*. 2013;45(9):8-15.
 28. Procop GW, Weathers AL, Reddy AJ. Operational aspects of a clinical decision support program. *Clin Lab Med*. 2019;39(2):215-229.
 29. Fleischut PM, Evans AS, Nugent WC, Faggiani SL, Kerr GE, Lazar EJ. Perspective: call to action: it is time for academic institutions to appoint a resident quality and patient safety officer. *Acad Med*. 2011;86(7):826-828.