

# Improving the Quality of Pediatric Healthcare through Quality Improvement Collaboratives

Raina Paul, MD<sup>1,\*</sup>

George R. Verghese, MD, MBA<sup>2</sup>

## Address

<sup>1</sup>Division of Emergency Medicine and Center for Excellence, Ann and Robert H. Lurie Children's Hospital of Chicago, Northwestern University Feinberg School of Medicine, 155 East Superior Street, Chicago, IL, 60611, USA  
Email: rpaul@luriechildrens.org

<sup>2</sup>Division of Cardiology and Center for Excellence, Ann and Robert H. Lurie Children's Hospital of Chicago, Northwestern University Feinberg School of Medicine, 225 East Chicago Avenue, Box 21, Chicago, IL, 60611, USA

Published online: 20 November 2017

© Springer International Publishing AG 2017

This article is part of the Topical Collection on *Quality Improvement*

**Keywords** Quality improvement · Quality improvement collaborative · Quality improvement networks · Pediatric healthcare delivery

## Opinion statement

*Purpose of review* This review summarizes the current need for Quality Improvement Collaboratives (QICs) and includes considerations specific to pediatric healthcare, such as low-frequency of outcomes and unique funding barriers. This review will consider nuances within measure formation and data collection within QICs, available models for structured formation of a QIC, components that are integral to a QICs success, as well as lessons learned and future directions.

*Recent findings* The literature has demonstrated an increase in the number of pediatric QI collaboratives in recent years. These collaboratives have varied in size, duration, and composition of team members. While some QICs have included members at the organizational level, others have included more novel groups such as insurance companies. Novel methodologies have also been utilized such as N of 1 trials focused on continued interventions for one patient and provider dyad. Successful QICs include use of a steering committee or pre-planning group to guide measures development, use of robust QI methodology to implement small tests of change and continuous feedback of individual and aggregate data and transparency among benchmarking sites. Ideal QI methods for use within QICs have been vetted in prior collaboratives and include formal barriers assessments using driver diagrams, PDSA cycles and analyzing data and measures using run and statistical process control (SPC) charts to inform real-time change and interventions.

*Summary* QICs are pivotal to closing the gap in delivery of evidence based practice while minimizing widespread unnecessary practice variation across multiple organizations using available QI methodologies and tools. Novel approaches to funding such as partnership with insurance companies and educational organizations can allow for more robust participation. Future research should broaden the scope of their measures to include patient centered outcomes.

## Introduction

Quality Improvement Collaboratives (QICs) have emerged as an effective way to disseminate existing evidence and develop best practices on a large scale to improve patient outcomes. Several pediatric improvement collaboratives have emerged in recent years; examples include the Children's Hospital Association's Quality Transformation Network [1] and the Ohio Children's Hospitals Solutions for Patient Safety [2], both of which have demonstrated the ability to improve outcomes and

reduce costs. They provide a model for other QICs during a time when there is an increasing urgency to demonstrate health care value—improved outcomes that matter to patients while reducing cost. The following article will describe the need for these collaboratives, key components of successful QICs, considerations in measures development, and data acquisition as well as lessons learned for future direction of QICs.

## What is a quality improvement collaborative?

A quality improvement collaborative is a multidisciplinary, multi-center, structured group of health care stakeholders with at least seven main features (Table 1). A QIC

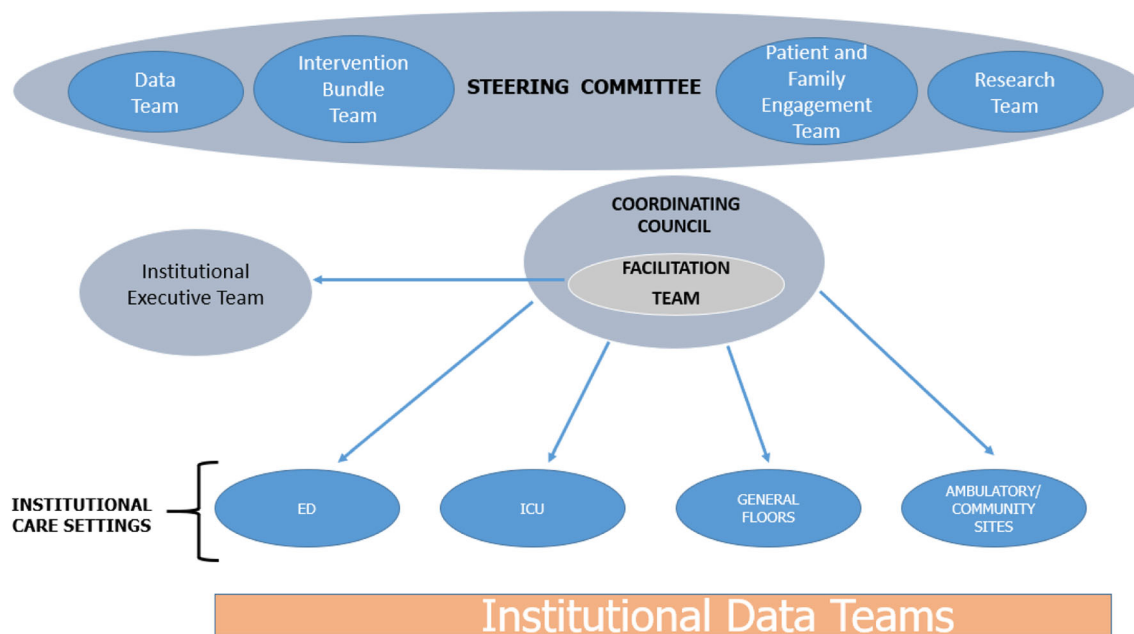
- a) forms multidisciplinary teams cross-cutting throughout an organization's hierarchical structure

**Table 1. The components that define a Quality Improvement Collaborative**

Components of a quality improvement collaborative	Description
Teams	Multidisciplinary with all relevant stakeholders Cross cutting across all levels of an organization
Global aim	Has a specific aim that targets not only processes but patient and provider level outcomes
Training	Provides just-in-time training regarding content specific education and quality improvement tools and methodology
Measures	Contains Outcome, Process, Structure and Balancing measures and provides a framework for data acquisition and continual reporting
Continual change	Fosters an environment where continual small tests of change can be implemented and evaluated
Cross collaboration	Creates infrastructure for participating teams to collaborate through use of techniques such as list-serves, shared portals and learning sessions

- b) aims to improve a specific provider practice to improve outcomes, patient-centered and otherwise
- c) trains members on content specific topics and QI related processes
- d) develops measures to be analyzed across the continuum of care
- e) provides a robust platform for data acquisition, entry, submission, and analyses
- f) fosters an environment where repeated tests of change are advised and encouraged and finally
- g) provides a method for facile cross-collaboration including collaborative specific extranet formation, listserves and virtual or in-person sessions. These components will be explored in more detail in later sections of this review.

A QIC has many hierarchical components that can be structured in many ways to maximize interaction between governance structures and local teams. An example of an effective QIC structure is demonstrated in Fig. 1. This structure includes a steering or pre-planning committee which contains several subgroups which meet before, during and after the collaborative. Within each institution exists a coordinating council team which involves key stakeholders from all relevant care settings and often includes physician-nurse dyads. Within the coordinating council group can exist a smaller group, the facilitation team, that meets more frequently to surmount barriers in real-time and ensure granular decisions do not impede institutional progress. This team will contain the operational champion who reports back to the executive team. Each care setting will include front-line members who have frequent local meetings, eliciting and reporting barriers, solutions and interventions to the larger group. Each institution will have a data team to



**Fig. 1.** An example of the organizational structure of a quality improvement collaborative

support data extraction and reporting as well as submission to the larger collaborative.

## Why is there a need for quality improvement collaboratives?

Many diseases within pediatrics have a low frequency of morbidity and mortality and chronic conditions are relatively uncommon. Unlike adult counterparts, many of the traditional quality metrics for disease conditions are rarely applicable to the pediatric population. Measuring outcomes from a single institution is often problematic. For example, death from septic shock in the adult population is as high as 20% yet the mortality rate for children is between 4 and 10%, the higher rates for those with chronic conditions [3]. As such, larger numbers of patients are needed to determine if QI interventions are changing outcomes such as mortality, morbidity, and quality of life metrics, thus fostering the need for collaboration. For example, the American College of Surgeon's National Surgical Quality Improvement Program-Pediatric (ACS-NSQIP-P) is a pediatric collaborative that has evolved over the years due to the observation that rates of "traditional" adverse events such as surgical site infections are much lower in children than adults [4]. Given the low frequency of adverse events for many pediatric conditions, combining data sources from many organizations is critical for yielding interpretable and significant results. For low-frequency conditions, sharing data can be very useful to highlight change early and recognize morbidity and mortality in a more robust and statistically significant way.

Institutions have their own individual culture, having delivered care in a routine, pre-determined way for many years. Due to these factors, there is tremendous variation in care across pediatric institutions [5]. By partnering with others, institutions can gain expertise from others, optimize interventions, enhance QI techniques and methodology, and ultimately create system level changes, allowing for a progressive change in culture and health care outcomes across organizations.

Government, organizations, and local institutions are calling on QICs to improve the quality of care delivery, especially following the release of the Institute of Medicine's landmark report "Crossing the Quality Chasm." [6] QICs are often charged with improving care using evidence based guidelines and real-time analyses of measures to ensure patient outcomes are optimized, acknowledging that the former may not always exist in rare pediatric conditions. The federal government has begun to support these collaboratives demonstrated, for example, by contributions totaling 30 million dollars over 3 years for the State Adolescent Treatment Enhancement and Dissemination grants [7]. Federal agencies such as the Agency for Healthcare Research and Quality (AHRQ) have continually supported coalition of ideas and progress through QICs for the past 25 years. Individual not-for-profit organizations such as the Children's Hospital Association (CHA) have emerged to push the quality agenda forward as it pertains specifically to pediatrics. CHA consists of 220 children's hospitals across the USA whose goal is to "advance child health through innovation in the quality, cost and the delivery of care" within children's hospitals [8].

QICs may also foster transparency of measures, allowing patients and families to identify institutions that may be performing at a higher level [9••]. Sites that participate in collaboratives are often dedicated to improving

outcomes, minimizing variation, containing costs, and benchmarking against peers to ensure continual improvement. Transparency and dissemination of best practices within a QIC are attractive characteristics for families seeking the most effective and safe care.

Finally, QICs allow payers to achieve their goals in a more meaningful way including purchasing value-based care, rewarding improvement, and reducing unnecessary variation for a variety of disease conditions. This allows payers to move away from traditional fee-for-service models which often does not incentivize providers and institutions to provide the most cost-effective and efficient care [9••].

## Quality improvement models within quality improvement collaboratives

There are several frameworks available for improvement, which the collaborative must decide a priori to utilize to provide a uniform approach for its participants. The Model for Improvement as adopted by the Institute of Healthcare Improvement (IHI) is a quality framework which utilizes rapid tests of change and real-time analysis [10]. This model utilizes the Breakthrough Series (BTS) method for collaboration which is designed to achieve rapid improvements that are measurable and sustained by allowing participants to integrate focused QI interventions into their everyday work [11]. The components of this model include formation of a planning group that identifies areas of change, aims of the collaborative, and potential barriers to achievement of goals. There is also an expectation that teams participate in pre-work which includes identifying members of multidisciplinary teams. These teams then participate in frequent virtual or in person learning sessions where they report upon their successes and failures, particularly as they pertain to their Plan-Do-Study-Act (PDSA) cycles, a vital component of the Model for Improvement.

Another framework is the Six Sigma/DMAIC (define, measure, analyze, improve, control) approach which also attempts to improve outcomes by minimizing variation in care. Lean methodology, developed by Toyota and used in industry for many years, aims to minimize waste in a system. Waste is defined as processes that fail to contribute value to the customer or patient. The provider and patient voice concern during any step of the process with the goal of optimizing efficiency [12] ([asq.org/learn-about-quality/six-sigma/overview/overview.htm](http://asq.org/learn-about-quality/six-sigma/overview/overview.htm)).

Some collaboratives also choose to base their work on existing data infrastructure as a launching pad for their QICs. An example of this is the Vermont Oxford Network QIC for neonatal intensive care which uses an existing database to analyze internal individual baselines and then aggregate benchmarking as groups move forward with QI interventions. Methods of evaluation include visits from QIC members at network sites and improvement is then guided by local culture and often self-study [13].

## The process of improvement

At the institutional level, once a collaborative is underway, a systematic approach to improvement must be made transparent. Each team within the collaborative must understand the steps from barriers assessment, to measure

development, to interventions and analysis, as described in the following paragraphs as adapted from Sundberg et al. [14]. There are several guides and techniques to achieve these steps, which have been well characterized by experts in the field [15, 16]. In the development of a QI plan, it is integral to begin with a vision statement, a description of the structure of the program, its membership, the meeting schedule and the list of the improvement goals that adhere to the tenets of a specific, measurable, achievable, relevant and time-bound (SMART) aim [16]. Once the aims are developed, key driver diagrams, fishbone diagrams, and process maps are used to assess the current state including existing barriers. Outcome, process and balancing measures are assigned to the key drivers within the driver diagram, as discussed further below. Interventions are then prioritized using tools such as Pareto mapping or the Possible, Implement, Challenge, Kill (PICK) chart and the principles of reliability science are followed. Measures are then tracked using ongoing time-series analysis including run and statistical process control charts which differ from traditional biostatistical techniques used in traditional medical research. If teams understand that every QI project follows these steps, they will be less apt to perceive that the process is slow or disorganized and will be more willing to contribute to the task at hand.

## Measures and components pertaining to QIC effectiveness

Once the quality improvement framework is chosen for the collaborative and the team members understand the steps through the process, it is important to recognize the components of a QI collaborative that promote success in achieving optimal outcomes.

Although there has been a rapid emergence of QICs in healthcare, there is still ambiguity as to which components of a collaborative truly confer improvements in outcomes. A review by Schouten et al. examined nine controlled studies of healthcare QICs. Many of them use matched controls or administrative data for comparison. Of these, two studies had positive effects on study outcomes, two found no difference and the remainder had mixed outcomes [17]. In this review, valued components of a QIC included sufficient expert team support, effective multidisciplinary teamwork, the use of the Model for Improvement with deliberate learning activities including PDSA cycles, and formal barriers assessment as described above. Similarly, a systematic review of five major healthcare databases by Erum et al. generated 20 different studies of quality improvement collaboratives, each with varying improvements in outcomes [18•]. Some components from this review that appeared to be of value for a successful QIC included contact with content and quality experts, formal PDSA cycles, in person and virtual learning sessions, and a shared extranet or listserv for participants to exchange ideas and benchmark in an informal way. Interestingly, this review noted that most recent studies continue to concentrate heavily on provider-level, rather than patient-level measures both in terms of tests of change, data collection, and outcomes which represent an area for continued improvement for future endeavors.

We have previously summarized healthcare quality improvement expert Dr. Brent James's recommendations for forming successful teams that can be applied and disseminated through a quality improvement collaborative [14]. In



general, the Institute for Healthcare Improvement (IHI) states that teams should include, although are not limited to, the following:

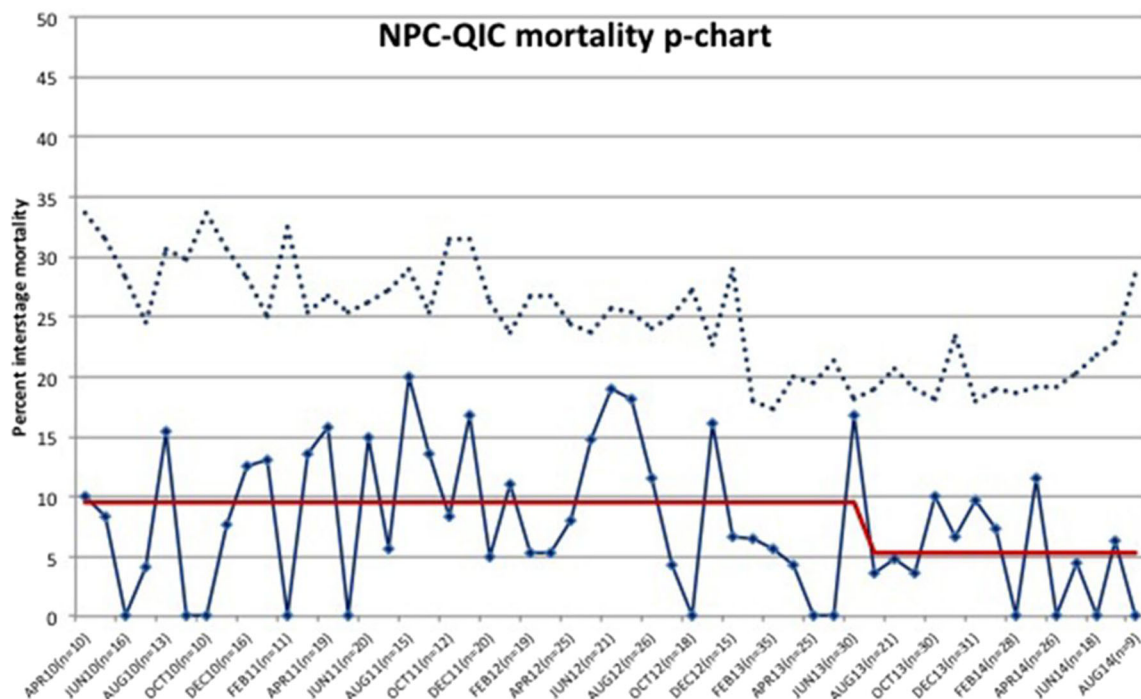
- (1) *Clinical leadership*: an understanding of the clinical care process institutionally and at the divisional level, is integral to how the change will affect clinical care. This individual should have the authority to test and implement change and problem solve issues on a global scale.
- (2) *Technical expertise*: this group possesses the understanding of the clinical process or area where the change will be occurring and includes front-line staff.
- (3) *Day to day leadership or Operational Lead*: this individual is the lead for quality improvement teams ensuring completion of data collection, analysis, and change implementation.
- (4) *Project lead or Executive Lead*: this individual serves as a link between the team implementing the work and senior leadership [19].

In considering ideal team composition, patients and their families should be at the forefront of a successful QIC. Several collaboratives have had success in implementing a true provider and patient/family centered partnership as their primary focus. This includes the National Pediatric Cardiology Quality Improvement Collaborative (NPC-QIC) and the Improve Care Now Network which give a voice to families from the forefront, allowing these key stakeholders to guide measure development, identify barriers to ideal care, and disseminate knowledge widely, often using social media platforms [20, 21]. Another patient-centered model is demonstrated by the Collaborative Chronic Care Network Project whereby “N-of-1” trials are conducted to determine the response of interventions using single patient and provider dyads as the unit of intervention over time [22].

## Measures development and data collection

Often the most time-consuming component of QIC is data acquisition. The pre-planning or steering committee should develop a measures grid to be presented to the larger QIC at the commencement of the collaborative. These measures should pertain directly to the global aim and include outcome, process, structure, and balancing measures. These measures are often garnered from the driver diagram as outlined by the IHI (<http://www.ihl.org/education/IHIOpenSchool/resources/Pages/AudioandVideo/Whiteboard9.aspx>). Using this model, the aim generates the outcome measures and the primary and secondary drivers or change strategies generate the process measures. *Outcome measures* are often those that matter most to the patient and clinicians, including but not limited to morbidity and mortality. They can reflect immediate outcomes such as percentage of patients with septic shock that receive the appropriate bundled care of antibiotics, fluids, and vasoactive agents, those that are more intermediate such as length of stay in the intensive care unit (ICU) for septic shock patients or long-term outcomes such as death from septic shock. Patient-reported outcomes are also important to include and often require patient and family engagement on the pre-planning committee. Cost and resource utilization metrics should also be incorporated into a QIC's outcomes. *Process measures* are more granular and can be influenced by the provider. They

may also demonstrate improvement before outcomes measures improve. If there is improvement in process measures, the outcome measure should improve as well. Allowing metric development to stem from a driver diagram will ensure that this natural link occurs. *Structural measures* address the system in which providers and families function and access healthcare, including electronic health record functionality and system-wide resources that can improve health (such as implementation of a patient portal). Finally, there should be at least one *balancing measure* included which attempts to ensure that the process is not functioning in a silo. As there is improvement in one aspect of system, inadvertent unintended consequences may emerge in another aspect and these should be measured as well. An example includes overuse of antibiotics while trying to improve care of those with septic shock. These metrics should then be visibly displayed in real-time using run or statistical process control (SPC) charts for all members of the QIC. The data should be reviewed and analyzed frequently, at least monthly, to allow for a granular understanding of interventions that may have created substantial change. A robust example of this is the National Pediatric Cardiology Quality Improvement Collaborative (NPC-QIC) which uses statistical process control to demonstrate meaningful improvements in process and outcome measures for infants with a relatively rare congenital heart disease population (hypoplastic left heart syndrome or HLHS) [23] (Fig. 2).



**Fig. 2.** Example of a statistical process control (SPC) chart published by the National Pediatric Cardiology Quality Improvement Collaborative (NPC-QIC), used to understand variation, direct real-time interventions, and demonstrate improvement in outcomes over time. From Publication (with permission): Anderson, JB, Beekman, R, Kugler JD. Improvement in Interstage Survival In a National Pediatric Cardiology Learning Network: For the National Pediatric Cardiology Quality Improvement Collaborative. Circ Cardiovasc Qual Outcomes. July 2015 [23]



In measure development for a QIC it is helpful to understand how pediatric measures may differ from existing measures for adult specific conditions. These can be described in terms of the 5 Ds: developmental change, dependency, differential epidemiology, demography and dollars [24]. Adult specific metrics are plentiful, but ought to be adapted using the guidance of these “5 Ds” to ensure applicability to the pediatric population.

Once measures have been generated using the above framework, the individual variables to be collected by members of the QIC for measure calculation must be outlined in detail. It is important to recognize that many institutions within any collaborative will have limited resources to collect data and thus the number of variables for QICs should be the minimum required to evaluate the pre-defined metrics. A robust data dictionary should accompany the variables, so sites within the QIC know exactly what each variable means, how each should be reported (string, numeric, free text etc.), as well as any existing limitations in variable reporting (exclusions, etc.). There are many possible data sources for a QIC. These include pre-existing disease registries, paper or electronic health records (EHR), patient surveys, and administrative databases. An example of the latter includes the CHA Pediatric Health and Information Systems (PHIS) databases, which houses administrative and clinical data for more than 6 million clinical cases [25]. A critical component in understanding resource limitations of some sites within a particular QIC is recognizing that some variables may require manual collection from the EHR while others can be automatically extracted. The former is often labor intensive and the latter often requires a large initial investment for data validation, thus appropriate time must be allotted for realistic submission deadlines.

## Lessons learned and future directions

Participation in multiple QICs and experiences of others nationally has yielded some important lessons for future work. The need for a formal data plan and measure development prior to the collaborative start as well as early validity testing to ensure that the collaborative runs smoothly cannot be underestimated. At times, QICs focus on other components, such as barriers assessment and PDSA cycles at the collaborative start only to lag behind in data acquisition and submission. The latter may result in a collaborative that is unable to rely on real-time data analysis to inform change which is a fundamental tenet of quality improvement work.

Prior QICs also provide insight around project funding. The national landscape for funding at the federal level is changing through programs such as Patient-Centered Outcomes Research Institute and the Agency for Healthcare Research and Quality [26–28]. This funding however is limited and support of data collection at the institutional level specifically, remains a challenge that has not yet been overcome as QICs continue to rely on voluntary contributions. Currently, many institutions pay substantial fees to participate in these collaboratives yet there is minimal funding available for those collecting data, disseminating frontline tests of change and reporting back to the QIC. A new funding paradigm is urgently

needed [29]. Some QICs have begun to partner with insurance entities who rely heavily on value-based care. These partnerships allow those that are clinically and academically invested to create measures that are relevant to the front-line provider and patient, while benefitting from the monetary compensation these companies can provide for tasks such as data collection (<http://www.bcbsm.com/providers/value-partnerships/collaborative-quality-initiatives.html>). Incentivizing providers is of utmost importance. Some methods used in previous QICs include incorporation into the Maintenance of Certification (MOC) program. The American Board of Pediatrics requires meaningful physician participation in assessing and improving quality of care, generating MOC Part 4 credit to pediatricians participating in the type of QI efforts [9••].

Another valuable lesson from prior QIC participation highlights the fact that there are many pediatric conditions where limited evidence is available. The number of metrics that have Grade A evidence is minimal. In evaluation of the Children's Hospital Program Reauthorization Act, only 2 of the initial 20 core measures had the highest evidence of Grade A [30]. As the evidence is not available, planning is of utmost importance to ensure that expert consensus to guide measure development is achieved. There is tremendous variation in practice, especially for conditions that do not have robust evidence based studies [5]. Variation does not emerge until experts from all geographic and demographic institutions are represented, but it is necessary to progress through the difficult task of consensus seeking to provide a uniform platform for eventual QIC members, acknowledging that iteration and refinement is anticipated.

Finally the future of QICs involves partnership with research and other entities. While several robust traditional research collaboratives demonstrate improvements at the cellular and physiologic level, it is only through true real-time partnership that we can ensure these interventions are disseminated to the population as a whole. It is also necessary to align technology with dissemination of best practices. For example, predictive analytics and artificial intelligence are becoming more widespread in healthcare and have a plethora of QI applications such as optimizing detection of unstable patients. Clancy et al. describe combining strategies of three distinct models within healthcare, a framework previously discussed in the literature [31, 32]. They detail collaboration amongst the following entities for effective QI collaboration: (a) research that has focused upon therapeutic discoveries that could have tremendous impact for the patient, (b) implementation of this knowledge by identification of the "right treatment, for the "right patient" in the "right way" at the "right time," and (c) "studies that address how to achieve health care change, including measurement and accountability, implementation and system redesign, scaling and spread, and learning from front line providers. An example of this type of collaboration has emerged in some centers such as that at the Children's Hospital of Philadelphia where they have developed the Pediatric Sepsis Program, one of the first comprehensive centers focused on pediatric sepsis that will combine QI and basic science discoveries to identify and rapidly treat septic shock patients to improve not only mortality but the long term morbidity of these patients, while simultaneously addressing the patient-centered outcome gap that is prevalent for this disease condition

(<https://newswise.com/articles/in-er-electronic-alert-helps-detect-severe-sepsis-in-children#>).

## Conclusion

Quality improvement collaboratives have an exciting future, as we learn to incorporate and integrate novel collaboration strategies to allow for the best possible outcomes for our patients. The potential to achieve breakthroughs in pediatric health care delivery are tremendous when we work collaboratively together and will necessitate a focused dedication to the sustainability and expansion of these programs in the future.

## Compliance with Ethical Standards

### Conflict of Interest

Raina Paul and George R. Vergheese declare no conflicts of interest.

### Human and Animal Rights and Informed Consent

This article does not contain any studies with human or animal subjects performed by any of the authors.

## References and Recommended Reading

Papers of particular interest, published recently, have been highlighted as:

- Of importance
- Of major importance

1. Miller MR, Niedner MF, Huskins WC, et al. National Association of Children's Hospitals and Related Institutions Pediatric Intensive Care Unit Central Line-Associated Bloodstream Infection Quality Transformation Teams. Reducing PICU central line-associated bloodstream infections: 3-year results. *Pediatrics*. 2011;128(5). Available at: [www.pediatrics.org/cgi/content/full/128/5/e1077](http://www.pediatrics.org/cgi/content/full/128/5/e1077).
  2. Blumenthal A. The stories behind the stats: NACHRI quality transformation network reaches milestone. *Pediatr Nurs*. 2011;37(5):276–8. 3. Ohio Children's Hospitals Solutions for Patient Safety. Available at: <http://solutionsforpatientsafety.org/>. Accessed 4 April 2013
  3. Watson RS, Carcillo JA, Linde-Zwirble WT, et al. The epidemiology of severe sepsis in children in the United States. *Am J Respir Crit Care Med*. 2003;167(5):695–701.
  4. Cameron DB, Rangel S. Quality improvement in pediatric surgery. *J Curr Opin Pediatr*. 2016;28(3):348–55.
  5. Wennberg JE. Dartmouth Atlas of Health Care. Available at: [www.dartmouthatlas.org](http://www.dartmouthatlas.org). Practice variation: implications for our health care system. *Manag Care*. 2004;13(supplement 9):3–7.
  6. Committee on Quality of Health Care in America and the Institute of Medicine, Crossing the Quality Chasm; 2001.
  7. Substance Abuse and Mental Health Services Administration Bulletin; Rockland. 2012. [www.Samhsa.gov](http://www.Samhsa.gov).
  8. Children's Hospital Association webpage: [www.childrenshospitals.org/About-Us/About-the-Association](http://www.childrenshospitals.org/About-Us/About-the-Association).
  9. •• Miles PV, Conway PH, Pawlson G. Physician professionalism and accountability: the role of collaborative improvement networks. *Pediatrics*. 2013;131(Supplement 4):S204–9.
- This seminal manuscript details how Quality Improvement Collaboratives and Networks can add tremendous value to multiple stakeholders in the healthcare area and postulates strategies to ensure ongoing collaborative work.**
10. Institute for Healthcare Improvement. The breakthrough series: IHI's collaborative model for achieving breakthrough improvement. IHI Innovation series white paper. Boston; 2003.
  11. Kilo CM. A framework for collaborative improvement: lessons from the institute for healthcare improvement's breakthrough series. *Qual Manag Health Care Summer*. 1998;6(4):1–14.

12. Mistry KP, Jagers J, Lodge A. Using six sigma methodology to improve handoff communication in high risk patients. In: Henriksen K, Battles JB, Keyes MA, et al., editors. *Advances in patient safety; new directions and alternative approaches (Vol 3: Performance and tools)*. Rockville: Agency for Healthcare Research and Quality; 2008.
  13. Horbar JD, Rogowski J, Plesek P, et al. Collaborative quality improvement for neonatal intensive care. *Pediatrics*. 107(1):14–22. <https://doi.org/10.1542/peds.107.1.14>.
  14. Sundberg M, Paul R, Verghese G. Teamwork and Collaboration. *Patient safety and quality in pediatric hematology/oncology and stem cell transplantation*; 2017.
  15. Berwick DM. A primer on leading the improvement of systems. *BMJ*. 1996;312(7031):619–22. <https://doi.org/10.1136/bmj.312.7031.619>.
  16. Langley G, Moen R, Nolan K, et al. *The improvement guide: a practical approach to enhancing organizational performance*. 2nd ed. San Francisco: Jossey-Bass; 2009.
  17. Schouten LMT, Grol RP, Hulscher ME. Factors influencing success in quality improvement Collaboratives: development and psychometric testing of an instrument. *Implement Sci*. 2010;5(1):1–9.
  18. Erum NS, Serene O, et al. Understanding the components of quality improvement Collaboratives: a systematic literature review. *Milbank Q*. 2013;91(2):354–94.
- This manuscript details in robust manner the potential components of successful QI collaboratives. It details the latest collaboratives in both pediatrics and adults and attempts to link successful components to outcomes, a novel approach.**
19. Langley GL, Moen R, Nolan KM, Nolan TW, Norman CL, Provost LP. *The improvement guide: a practical approach to enhancing organizational performance*. 2nd ed. San Francisco: Jossey-Bass Publishers; 2009.
  20. National Pediatric Cardiology Quality Improvement Collaborative. For parents by parents <http://jcchdq.org/parents>; 2012.
  21. Families. *Improve Care Now*. <https://improvecarenow.org/families>; 2012.
  22. Collaborative Chronic Care Network. N of 1 trials. <http://c3nproject.org/innovations/n-1-trials>. 2012.
  23. Anderson JB, Beekman R, Kugler JD. Improvement in interstage survival in a national pediatric cardiology learning network: for the national pediatric cardiology quality improvement collaborative. *Circ Cardiovasc Qual Outcomes*. 2015;8:428–36.
  24. Adirim T, Kelley MK, Kamila M et al. A new era in quality measurement: the development and application of quality measures. *Pediatrics*. 2017; 139(1).
  25. Pediatric Health Information System. Children’s Hospital Association. Available at: <http://www.childrenshospitals.org>. Accessed 31 Oct 2012.
  26. Agency for Healthcare Research and Quality. Grants on-line database. Factors Associated with Quality of Care Delivered to Children in US EDs. Available at: [http://gold.ahrq.gov/projectsearch/grant\\_summary.jsp?grant¼R01þHS19712-03](http://gold.ahrq.gov/projectsearch/grant_summary.jsp?grant¼R01þHS19712-03). Accessed 3 Oct 2017. 36.
  27. Agency for Healthcare Research and Quality. Grants on-line database. Improving the Quality of Pediatric Emergency Care Using an Electronic Medical Record. Available at: [http://gold.ahrq.gov/projectsearch/grant\\_summary.jsp?grant¼R01þHS20270-02](http://gold.ahrq.gov/projectsearch/grant_summary.jsp?grant¼R01þHS20270-02). Accessed 2 Oct 2017. 37.
  28. Agency for Healthcare Research and Quality. Grants on-line database. ParentLink: Better and Safer Emergency Care for Children. Available at: [http://gold.ahrq.gov/projectsearch/grant\\_summary.jsp?grant¼R01þHS14947-02](http://gold.ahrq.gov/projectsearch/grant_summary.jsp?grant¼R01þHS14947-02). Accessed 3 Oct 2017.
  29. Miller M, Wietecha M. Keeping children healthy. Fresh approaches are sorely needed to expand pediatric HAI prevention efforts. *Mod Healthc*. 2012;42(1):22.
  30. Grades of Recommendation, Oxford Centre for Evidence Based Medicine. Available at: [www.cebm.net/index.aspx?o=1047](http://www.cebm.net/index.aspx?o=1047). Accessed 1 Oct 2017.
  31. Dougherty D, Conway PH. The 3 Ts roadmap to transform U.S. healthcare: the “how” of high-quality care. *JAMA*. 2008;299(19):2319–21.
  32. Clancy C, Margolis P, Miller M. Collaborative networks for both improvement and research. *Pediatrics*. 2013;13(Supplement 4):S210–4.