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Quality of care and safety measures of acute renal replacement therapy: Workgroup statements from the 22nd acute disease quality initiative (ADQI) consensus conference

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ABSTRACT

Purpose: There is wide variation in the practice of acute renal replacement therapy (RRT). Quality of care is suboptimal, and substantial knowledge-to-care gaps need to be addressed. The quality of care for patients receiving acute RRT has been recognized as a clinical and research priority. Quality indicators (QIs) can be implemented to measure the quality of care received by patients and further be used as targets for continuous quality improvement initiatives focused on the prescription, delivery, and monitoring of acute RRT care.
Methods: The 22nd ADQI meeting was held in San Diego, USA, from October 28th to 30th 2018. Prior to the meeting, a literature review was conducted, and 3 teleconferences were held to develop research questions and consensus statements. These were presented at the meeting and refined before being approved by all ADQI delegates.
Results: Four research questions and fifteen consensus statements were generated. These focused on monitoring the quality of acute RRT along with the Donabedian quality measure domains of structure, process, and outcome. Recommendations for clinical practice and a research agenda for each question were also proposed.
Conclusion: Currently, there remains few validated QIs for acute RRT. These need further evaluation, need benchmarks established, and ultimately require implementation into clinical practice.

1. Introduction

There are few studies that have examined the quality of care provided to patients with acute kidney injury (AKI), specifically those receiving treatment with acute renal replacement therapy (RRT). Selected studies suggest that the quality of care received by these patients is subject to wide practice variation and is suboptimal [1,2]. For instance, the landmark report by the National Confidential Enquiry into Patient Outcome and Death (NCEPOD) identified that only 50% of hospitalized patients dying with AKI received 'good' care, and fewer than a third with hospital-acquired AKI received adequate care [3]. Hence, there are increasing efforts aimed at not only improving the general care provided to patients with AKI but also developing new standards for high-quality care specific for AKI and acute RRT [4-7]. To this end, several organizations including the 'Acute Disease Quality Initiative' (ADQI) and 'Kidney Disease: Improving Global Outcomes' (KDIGO) have worked towards implementing evidence-informed clinical practice guidelines and developing research priorities for acute RRT care [8,9].

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Table 1
Previous identified quality indicators for CRRT.

Study	Structure	Process	Outcomes
Systematic Review	• Filter life • Blood flow • Filter efficacy • SCT training	• Adherence to protocol • Catheter colonization • Cather malfunction • Delivered dose • Downtime • Effluent volume • Fluid management • Interruptions • Small solute clearance	• Bleeding • Complications • CRBSIs • Thrombocytopenia • VTE events
Delphi Process	• Filter life • SCT training	• Delivered dose • Downtime • Fluid management • Medication adjustment • Time from prescription to therapy • Therapy prescription	• Adverse events • Bleeding • Catheter dysfunction • CLABSIs

CLABSI – catheter line-associated bloodstream infection; CRBSI – catheter-related bloodstream infection; SCT – specialized care team; VTE – venous thromboembolism.

Despite the abovementioned initiatives, there remains limited data on quality indicators (QIs) for acute RRT. This has created numerous challenges for understanding the relative quality and safety of acute RRT along with the limited capacity to monitor, report, and benchmark performance. One of the main challenges has been identifying evidence-based QIs. QIs represent methods to measure, monitor, evaluate, and communicate targeted areas of the healthcare system to assess whether and how often it does what it is intended to do [7]. QIs have classically been described using the Donabedian framework, assessing the structure (i.e., where healthcare is delivered), process (i.e., how healthcare is delivered) and outcomes (i.e., the effects of healthcare delivery) [10]. A recent systematic review identified 18 potential QIs for continuous renal replacement therapy (CRRT) using the Donabedian domains of structure, process, and outcomes [11]. A Delphi process further refined these QIs to arrive at a prioritized list of 13 QIs that may be considered for inclusion into clinical practice and for development of a quality dashboard for any CRRT program (Tables 1 and Table 2). [12] However, these QIs are generally limited to CRRT and do not encompass the full spectrum of acute RRT therapies that are used to treat AKI (Table 3).

An additional barrier to the delivery of consistently high-quality care to patients with AKI treated with acute RRT is the variation in clinical practice for how acute RRT is prescribed, monitored, and delivered. This practice variability may stem from several sources, including variable services and operational models for providing RRT (e.g., nephrology, intensive care, both), knowledge gaps in the evidence base for acute RRT, and failure to adequately adopt best practices supported by high-quality evidence from clinical trials [7,13,14]. Indeed, such variability can be a risk for the delivery of suboptimal quality of care and/or less favorable outcomes [13,14]. We submit the integration and routine measurement of acute RRT specific QIs are essential for improved standardizations of practice, identification of knowledge-to-care gaps, facilitating improved reliability of RRT delivery, and identifying opportunities for continuous quality improvement (CQI). Our objective was to put forward methodology for integrating potential QIs into clinical practice and propose an agenda for research to evaluate and validate these QIs.

Table 2
Proposed quality dashboard for CRRT.

Quality Indicator	Operational definition	Proposed Benchmark
Filter life	Number of filters lasting 60 h/Total number of filters used	>60% filters
Delivered Dose	(Actual delivered dose/24 h)/(Prescribed dose/24 h)	>80% of dose
Fluid management	(UF removed/24 h)/(Prescribed UF/24 h)	>80% of ultrafiltrate
Small solute clearance	[sCr (d1) – sCr (d2)]/[sCr (d2)]	No increases (i.e., change ≤0%)
Downtime	Hours off CRRT/24 h	< 10% of the time
Adverse events	# of adverse events (i.e., machine alarms)/ number of patients on CRRT	0 events
Catheter dysfunction	# of catheters, dysfunction-free/# of catheters with dysfunction	≥80% of catheters
CLABSIs	CLBSIs/# Catheter-line days	0 events/catheter

Quality Indicators that may be used as part of a CRRT Quality Dashboard. These include process (light grey) and outcome (dark grey) indicators. Structure indicators would be part of the framework of a CRRT program and may include a CRRT committee, defined training program, standardized CRRT order sets, infrastructure to support and measure these ongoing quality indicators and a process to ensure the proper functioning of CRRT machines. CLABSI – catheter line-associated bloodstream infections; CRRT – continuous renal replacement therapy.

2. Methods

The methodology of ADQI consensus meetings are well developed and have undergone refinement in the last two decades [15]. The aim of ADQI is to provide expert-based statements, supported by evidence where applicable, and interpretation of current knowledge for use in clinical care by healthcare professionals and decision-makers. These healthcare professionals included physicians (i.e., nephrologists and intensivists), nurses and nurse educators, as well as allied health professionals (i.e., pharmacists). In addition, ADQI aims to identify evidence and knowledge-to-care gaps to establish future research priorities. The 22nd ADQI consensus meeting convened a diverse panel of experts representing the disciplines of nephrology, critical care, nursing, pharmacology, epidemiology, and biostatistics and medical informatics around the theme of "Improving Care for Patients with AKI" for a 3-day meeting in San Diego, USA (October 28–30, 2018) [8,16].

The ADQI methodology begins with a pre-conference comprehensive literature search and appraisal of scientific evidence to identify key themes. The core theme for this workgroup centered on "quality measures in acute RRT." The workgroup summarized areas where there is consensus supported by evidence, consensus but limited or no evidence and existing knowledge gaps where consensus was uncertain. The workgroup identified four core themes to generate questions for presentation to the ADQI delegates during the meeting. The workgroup iteratively developed and refined consensus statements in response to each core question. Core questions and statements were presented during five successive plenary sessions involving all ADQI delegates for debate, discussion, suggested revisions, and final consensus. Following the conference, this summary review of the process and final content was generated, reviewed, and approved by all (Table 3).

Question 1. How should the quality of acute RRT be monitored, evaluated, and reported?

3. Consensus statements

1. Quality indicators for intermittent RRT (IRRT), including intermittent hemodialysis (IHD) and prolonged intermittent RRT (PIRRT), peritoneal dialysis (PD) and continuous renal replacement therapy (CRRT) should be implemented in routine clinical practice for acute IRRT delivered both in intensive care unit (ICU) and hospital ward settings.
2. Acute RRT programs should integrate structure, process, and outcome quality indicators for each therapeutic modality, both in ICU and the hospital ward settings.

3.1. Rationale

Quality of acute RRT should be monitored to ensure the effective and safe delivery of care. QIs need to encompass all aspects of acute RRT,

Table 3
Summary of core questions focused on "quality measures in acute RRT."

Core Questions for "Quality Measures in Acute RRT"	
1	How should the quality of acute renal replacement therapy be monitored, evaluated, and reported?
2	What are the minimum structure indicators that should be implemented for the provision of acute RRT?
3	What are the minimum process indicators that should be implemented for the provision of acute RRT?
4	What are the minimum outcome indicators that should be implemented for the provision of acute RRT?

RRT – renal replacement therapy.

including patients transitioning from differing areas of the intensity of care while still receiving RRT. In order to ensure their broad uptake, quality of care and QIs must be incorporated into educational and training programs. These programs should target not only frontline healthcare professionals involved in the prescription and delivery of acute RRT (i.e., physicians and nurses) but also inter-professional allied health personnel involved in the care of patients undergoing acute RRT (i.e., pharmacists, dieticians, physiotherapists, and occupational therapists). They should target multi-level learners on the importance of QIs, quality improvement methodology, and rationale for iterative evaluation and benchmarking.

Providing appropriate and adequate education is a vital step to identify and address potential barriers to implementation of QIs. Barriers may include the cost of QI implementation, heterogeneous definitions, and lack of robustly determined QI benchmarks, as well as organizational and technological limitations for the implementation of these QIs. Industry, medical leaders, and policy-makers will need to ideally partner as stakeholders in order to integrate QIs. QIs will need to be defined with future studies done to determine robust and achievable benchmark targets. These QIs should not be linked to program accreditation and remuneration until evidence-based benchmarks are rigorously defined and endorsed by the National Quality Forum and leading critical care nephrology quality-focused organizations (i.e., KDIGO) [9,17,18].

3.2. Recommendations for clinical practice

All institutions that provide acute RRT should adopt and implement a quality framework around acute RRT services. At a minimum, this should include the integration, monitoring, and reporting of structure, process, and outcome indicators across all forms of acute RRT therapies (Fig. 1). These should be adapted as necessary to the clinical setting for acute RRT delivery (i.e., ICU or ward).

3.3. Recommendations for research

- Future work should evaluate target benchmarks for each QI that can inform about patient-specific and aggregate institutional quality of care.
- Future resources should be directed towards developing and refining a multi-center acute RRT registry to further develop, validate, and refine QIs that identify target benchmarks for clinical practice guidelines. [19]

Question 2. What are the minimum structure QIs that should be implemented for the provision of acute RRT?

3.4. Consensus statements

1. Structure quality indicators should specifically target clinician capacity and expertise for providing acute RRT services (i.e., intensivist and/or nephrologist or alternative trained clinicians).
2. Structure quality indicators should specifically target nursing capacity and expertise for delivering acute RRT services (i.e., ICU, nephrology nurses, or alternatively trained clinicians).

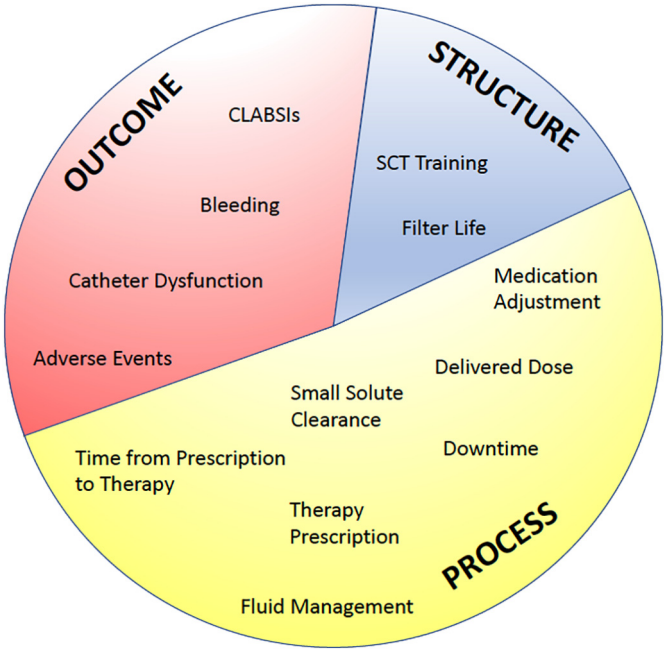

Fig. 1. Depicted above are 13 evidence-based CRRT quality indicators from a recent Delphi-process which prioritized these quality indicators as stratified by the Donabedian domains of structure, process and outcome. CLABSI – catheter line-associated bloodstream infection; SCT – specialized care team. Source: Acute Disease Quality Initiative XXII; www.adqi.org. Used with permission.

3. Structure quality indicators should specifically target the availability of multidisciplinary professionals (i.e., pharmacy; dietary; rehabilitation; biomedical engineering; clinical nurse educators) who concomitantly support acute RRT programs.
4. Structure quality indicators should identify a responsible team to implement and report quality indicators for acute RRT services, including the capture and monitoring of quality indicator data and developing/implementing a quality assurance process.
5. Structure quality indicators should establish local operational standards, including policies, procedures, and protocols for acute RRT services.
6. Structure quality indicators should determine the availability of technology (i.e., RRT machines, catheters, etc.) and leverage electronic health record (EHR) capability to capture selected quality indicators, if applicable.

3.5. Rationale

Structure indicators should focus on ensuring that all necessary resources, including personnel, technology, and infrastructure, are available. In addition, standardized operational parameters, suited to the institutional or regional context, should be established. A key structure QI should focus on the identification of an individual or a multidisciplinary team that will be responsible for the quality framework for acute RRT services in a given institution or region [20]. Such persons or members of the team should have expertise in health care quality and safety, and be accountable for the implementation, monitoring, and reporting of the QIs. When available, utilization of the EHR and bedside clinical information can provide an opportunity for automated capture, calculation, and reporting of a wide variety of process QIs. These QIs can be integrated into clinical and/or administrative databases (i.e., data repositories or registries) or to a specific acute RRT quality registry to develop new QIs, or further refine existing ones. Such repositories can be leveraged to establish benchmark targets for both experienced acute RRT institutions and those establishing new acute RRT programs.

3.6. Recommendations for clinical practice

Institutions that provide acute RRT should establish standards for structural QIs that incorporate evaluation of resource availability and the infrastructure for providing RRT. At a minimum, this should include:

1. Incorporation of a team, comprised of expert clinicians, nurses and allied professionals, that are responsible for the monitoring and reporting of QI data, as well as the creation and implementation of QI processes for each acute RRT modality offered.
2. Establishment of operational standards, including policies, procedures, and protocols for each acute RRT modality offered.
3. Evaluation of the equipment and supplies utilized (i.e., RRT machines, catheters, etc.) to ensure optimal use and maintenance.

3.7. Recommendations for research

- Future work should rigorously evaluate specific structure QIs and correlate these with the process of care and outcome QIs for acute RRT.
- Future work should rigorously evaluate target benchmarks for each QI that can inform about the patient-specific and institutional quality of care.
- Future resources should be directed towards developing a multi-center acute RRT registry to further develop, validate, and refine QIs for implementation into routine practice and informing on ideal target benchmarks for integration into updated clinical practice guidelines [21].

Question 3. What are the minimum process indicators that should be implemented for the provision of acute RRT?

3.8. Consensus statements

1. Process quality indicators should incorporate methodology that standardizes procedures and protocols, allowing for greater consistency in care and safety.
2. Process quality indicators should specifically target RRT efficiency parameters including dose delivered vs. prescribed, metabolic control, and volume control.
3. Additional process quality indicators should target individual determinants of RRT efficiency including time between RRT decision and initiation (including time to catheter placement/replacement), protocol adherence, and treatment downtime (e.g., time off the machine and other delays).
4. Process quality indicators specific to each modality are required. CRRT should include filter lifespan, whereas IRRT should include treatment sessions requiring >1 filter (i.e., unplanned filter change).

3.9. Rationale

Process QIs focus on ensuring the delivery of consistent, high-quality RRT care. An important process indicator is the degree of standardization of procedures and methodology. Standardization, facilitated through the development of protocols, and adherence to such procedures/protocols, improves consistency in care, safety, and communication, and thus provides the basis for quality evaluation of any acute RRT program.

Process QIs for RRT should evaluate the performance of the RRT treatment itself, as well as achievement of the goals of acute RRT (i.e., control of azotemia, acid-base and electrolyte derangement, and fluid overload). Randomized trials have shown that augmented CRRT dose is not associated with improved patient outcomes. Based on both the Acute Renal Failure Trial Network (ATN) study and the Randomized Evaluation of Normal versus Augmented Level Replacement Therapy Study (RENAL) an effluent rate of at least 20–25 mL/kg/h should be prescribed for CRRT as long as careful attention is given to ensure that the target dose of therapy is actually delivered [22,23]. For IRRT, treatments three times a week are sufficient for solute clearance as long as a target Kt/Vurea >1.2 per treatment is achieved. As a result, process QIs should at a minimum focus on measuring and achieving these evidence-based standards for RRT dose. If target dosing is not achieved, then additional process QIs should be developed to evaluate for potential causes contributing to the inadequate delivery of RRT dose or inability to meet clinical goals. Fluid management, as measured by volume removal should be considered in a similar fashion as dose; the patient is evaluated, and subsequent fluid management is prescribed, targets are determined, and these goals should be monitored to assess the performance of delivered RRT. For CRRT, unplanned loss of the circuit contributes to lower average delivered effluent dose and ultrafiltration, potential blood loss, increased nursing workload, and increased costs. Although no agreement on specific targets exists, achieving institutional targets for circuit life is a key QI to assess in patients receiving CRRT. Other process QIs for consideration should focus on aspects of anticoagulation, dialysis access, fluid management, and appropriate drug dosing.

3.10. Recommendations for clinical practice

Institutions providing acute RRT should incorporate standardized clinical protocols for each RRT modality in order to deliver consistent and safe care. Key measures of RRT adequacy should be routinely measured and reported. These include delivered dose of RRT, and determining whether metabolic and volume targets are being met. The implementation of quality improvement methodologies should be conducted when there are significant deviations in a QI (Fig. 2). These quality processes will be directed by root cause analyses, which identify gaps in the delivery of care, and an analysis of the patterns of these gaps (Fig. 3).

3.11. Recommendations for research

- Future studies should further evaluate specific process QIs and correlate these with outcome indicators for acute RRT.
- Future studies should evaluate target benchmarks for each QI that can inform about patient-specific and aggregate institutional performance.
- Future resources should be directed towards developing a multicenter acute RRT registry to further develop, validate, and refine QIs for implementation into routine practice and informing on ideal target benchmarks for integration into updated clinical practice guidelines.

Question 4. What are the minimum outcome indicators that should be implemented for the provision of acute RRT?

3.12. Consensus statements

1. Outcome quality indicators should target patient-centered outcomes such as survival, duration of RRT, and recovery of kidney function/discontinuation of RRT.
2. Outcome quality indicators should incorporate adverse events related to acute RRT.
3. Outcome quality indicators should consider integrating AKI survivor-related outcomes, including changes in baseline kidney function, rehospitalization rates due to kidney-related complications within 30-days after discharge and patient experience-related outcomes such as patient satisfaction and health-related quality of life.

3.13. Rationale

The ultimate goal of quality processes is to improve patient outcomes. This should not be limited to patient survival, but rather comprise a variety of metrics that incorporate patient survival, patient-centered acute RRT outcomes, safety, AKI survivor-reported outcomes,

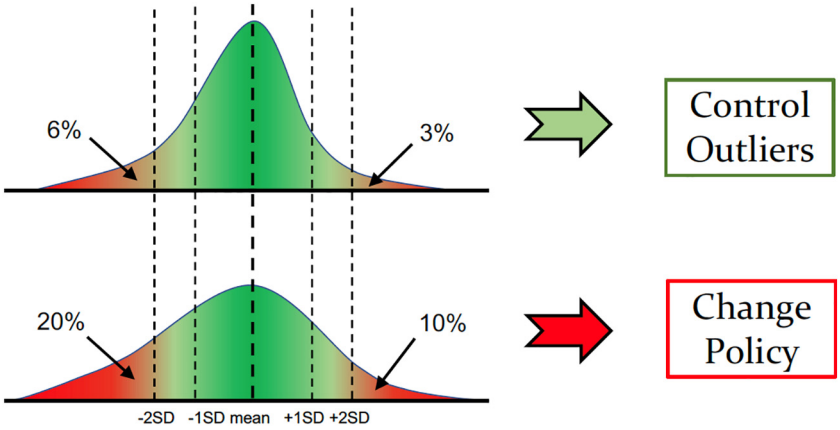

Fig. 2. Depicted above are potential findings from monitoring the performance in CRRT. In the top figure, there is a small percentage of causes that fall outside of the expected deviations from the mean. In this case, we evaluate these outliers. However, in the figure below, the incidence of deviation from the mean in higher. Hence a review of the unit policy is required to ensure decreased practice and performance variability. SD – standard deviation. Source: Acute Disease Quality Initiative XXII; www.adqi.org. Used with permission.

and patient experience. Patient-centered acute RRT outcomes include the duration of RRT and rate or renal recovery. Outcome QIs should encompass measures of each one of these parameters and assess them regularly. This not only allows every center to compare their institution's actual vs. expected QI outcomes (for each of the aforementioned parameters) but also track their trends over time so that the efficacy of their quality processes can be determined.

While no single intervention (e.g., therapy modality, medication, etc.) has been demonstrated to improve mortality in patients with AKI, trends in mortality have temporally decreased over time. [24] A possible explanation may be due to overall better supportive care and improved safety by decreasing adverse events. Common potentially avoidable complications can be classified into; *i*) those that contribute to unplanned blood transfusions, *ii*) catheter-related, *iii*) metabolic, and *iv*) episodes of iatrogenic hemodynamic instability and hypotension. Because avoidable complications are well-established contributors to morbidity and mortality, as well as long-term morbidity of survivors, it is imperative that these iatrogenic adverse events be monitored, and a root-cause analysis conducted (Fig. 3) [25].

It is recognized that AKI survivors incur increased risk for long-term complications, including impairment in long-term health-related quality of life [26]. Thus, factors that impact the long-term health of these patients constitute important metrics to monitor. The most widely recognized are incident or worsened CKD and end-stage kidney disease, which are associated with an increased rate of cardiovascular events and death. While other factors may also contribute to impaired quality of life, the ongoing dependence on RRT following discharge is certainly a leading factor. But even lesser decreases in kidney function may contribute to impaired fluid homeostasis and accumulation and greater risk of rehospitalization, particularly in patients who were discharged while still overloaded [27]. Thus, evaluating factors that may influence kidney recovery and its related complications (e.g., severity and duration of AKI and the controversial IRRT vs. CRRT). It is important to note that while short-term morbidity after severe AKI is significant, many patients still experience reductions in their quality of lives after 5 years, submitting that long-term changes in quality of life may be an important patient-centered outcome to be considered [28].

Patient-centered endpoints can be proposed as outcome QIs, though it may be challenging to establish benchmark targets. They are influenced by multiple factors including patient variability, severity of illness, and differences in concomitant care, many of which cannot be identified or their impact quantified. They can be used for internal benchmarking, and with careful case-mix adjustment accounting for the aforementioned factors, can be used to benchmark performance between institutions. This may be especially true for large quality improvement or patient registries such as the CRRT network [19].

3.14. Recommendations for clinical practice

Institutions and programs providing acute RRT should integrate, monitor, and report outcome QIs for acute RRT. The monitoring of adverse events is vital to ensure that acute RRT is being delivered in a safe and high-quality manner. Furthermore, long-term patient-centered outcomes must be considered to ensure that acute RRT is being initiated and administered in a fashion aligned with important patient values. Programs should set target benchmarks for each QI that are context-specific and customized to the individual institution. When there is significant deviation in outcome QIs, a root-cause analysis should be conducted to determine and address these deficiencies.

3.15. Recommendations for research

- Future work should further evaluate the association of specific outcome indicators and health system value (i.e., outcome achieved relative to health care costs) for patients, institutions, and health systems.
- Future work should evaluate target benchmarks for each QI that can inform about the patient-specific quality of care and aggregate institutional quality of care.

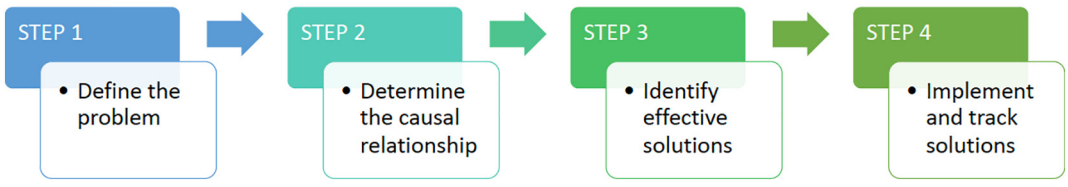

Fig. 3. This is a 4-stage analysis that facilitates the creation of a common reality, using input from all stakeholders to produce an evidence-based understanding of the problem and ensures that the solutions address proven causes to prevent recurrences. Source: Acute Disease Quality Initiative XXII; www.adqi.org. Used with permission.

- Future resources should be directed towards developing a multicenter acute RRT registry to further develop, validate, and refine quality measures for implementation into routine practice and informing on ideal target benchmarks for integration into updated clinical practice guidelines.

3.16. Strengths/limitations

While this consensus process has strengths, such as the inclusion of diverse inter-professional membership and the development of evidence-informed consensus statements to guide clinical practice and future research on quality in acute RRT; there are also limitations that warrant consideration. For example, members of the work group were generally representative of high-income countries and academic centers, as such, consensus statements may not reflect the nuanced challenges of providing acute RRT in lower resource and/or non-academic settings. However, we aimed to present a broad range of generalizable QIs that could be implemented across a spectrum of healthcare settings. In addition, we recognize that most available evidence for QIs in acute RRT stems from literature focused on CRRT [29]. Finally, we have proposed initial targets for benchmarks from our list of QIs that may be integrated into a CRRT Quality Dashboard (Table 3). However, as evidence evolves on quality in acute RRT and as selected indicators may be implemented into local acute RRT programs, we submit these targets should be iteratively revisited and revised accordingly.

4. Conclusions

Quality measures for acute RRT should be implemented and evaluated in the routine clinical application of acute RRT. Acute RRT care should be monitored, reported, and benchmarked. Future steps require identification, development, and validation of QIs across the domains of structure, process, and outcomes.

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Conflicts of interests

OGR, SMB, TAM, LAJ, and AT have consulted and received honoraria from Baxter Healthcare Corp.

TAM has consulted and received honoraria from Medtronic.

MH has received honoraria fees from Abbott, Alere, Astute, Baxter, Novartis, Roche, and Siemens.

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