Quality-of-Care Indicators for Children With Sickle Cell Disease

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Quality-of-Care Indicators for Children With Sickle Cell Disease

C. Jason Wang, Patricia L. Kavanagh, Alison A. Little, Jaime Bruce Holliman and Philippa G. Sprinz

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Quality-of-Care Indicators for Children With Sickle Cell Disease

WHAT'S KNOWN ON THIS SUBJECT: Existing guidelines and policy statements for the management of children with sickle cell disease (SCD) do not provide the specificity required for quality assessment and quality improvement. Children with SCD continue to be at risk for morbidities and early mortality.

WHAT THIS STUDY ADDS: A set of quality indicators for children with SCD was developed through an expert-panel process after a systematic review of available evidence. Institutions can use these indicators to begin to measure and improve quality of care for these children.

abstract

OBJECTIVE: To develop a set of quality-of-care indicators for the management of children with sickle cell disease (SCD) who are cared for in a variety of settings by addressing the broad spectrum of complications relevant to their illness.

METHODS: We used the Rand/University of California Los Angeles appropriateness method, a modified Delphi method, to develop the indicators. The process included a comprehensive literature review with ratings of the evidence and 2 rounds of anonymous ratings by an expert panel (nominated by leaders of various US academic societies and the National Heart, Lung, and Blood Institute). The panelists met face-to-face to discuss each indicator in between the 2 rounds.

RESULTS: The panel recommended 41 indicators that cover 18 topics; 17 indicators described routine health care maintenance, 15 described acute or subacute care, and 9 described chronic care. The panel identified 8 indicators most likely to have a large positive effect on improving quality of life and/or health outcomes for children with SCD, which covered 6 topics: timely assessment and treatment of pain and fever; comprehensive planning; penicillin prophylaxis; transfusion; and the transition to adult care.

CONCLUSIONS: Children with SCD are at risk for serious morbidities and early mortality, yet efforts to assess and improve the quality of their care have been limited compared with other chronic childhood conditions. This set of 41 indicators can be used to assess quality of care and provide a starting point for quality-improvement efforts. *Pediatrics* 2011;128:484–493

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KEY WORDS

quality indicators, quality of care, sickle cell disease

ABBREVIATIONS

SCD—sickle cell disease
TCD—transcranial Doppler
ACS—acute chest syndrome
AVN—avascular necrosis
RHCM—routine health care maintenance

Dr Wang oversaw the entire project, including the study design, literature review, expert-panel process, analysis of data and write-up; Dr Kavanagh led the literature review and assisted in the expert-panel and writing process; Ms Little and Ms Holliman assisted in the literature review, expert-panel process, analysis of data, and write-up; and Dr Sprinz contributed significantly to the literature review, the expert-panel process, and the revision of the manuscript and was the hematologist on the team. All the authors approved the final version submitted for publication.

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Each year, ~2000 children in the United States are born with sickle cell disease (SCD),[1] and estimates suggest that 70 000 to 100 000 people in the United States are currently living with SCD.[2] SCD encompasses several related diagnoses, all of which involve the presence of hemoglobin S.[3] Children with SCD are at risk for serious morbidities related to vaso-occlusion, hemolysis, and infection,[4,5] which can impair quality of life[6] and lead to early mortality.[7] Common complications include pain episodes, acute chest syndrome, stroke, and invasive pneumococcal disease.[1,4]

In the past few decades, there have been several advances in the clinical management of SCD in children. For example, penicillin prophylaxis,[8] pneumococcal vaccination,[9] and broader spectrum antibiotics have been used to prevent and treat infections.[10] Many children at high risk of stroke can be identified by using transcranial Doppler (TCD) screening[11,12] and managed with regularly scheduled blood transfusions.[11,13,14] Together with newborn screening for hemoglobinopathies,[15] these interventions have helped increase the median life expectancy for patients with SCD from <15 years in the 1970s to >40 years by the 1990s.[16] Still, adverse outcomes remain common among children with SCD. Recent findings from the Dallas Newborn Cohort indicate that ~6% of patients with an SCD diagnosis of HbSS or HbSβ^0 still die during childhood.[7]

There is evidence that gaps and variations in quality of care may contribute to poor outcomes for children with SCD. Mortality rates vary substantially according to geography. Using data collected from 1981 to 1992, Davis et al[17] showed that in Florida, black children younger than 4 died from SCD at more than double the national rate (16.2 deaths per 1000 patient-years versus 6.8 deaths per 1000 patient-years). In contrast, Maryland's mortality rate from SCD during the same period was far below the national average (0.8 deaths per 1000 patient-years).[17] These disparate outcomes suggest that care received by children with SCD may be highly variable.[15] In addition, a recent study revealed that ~7% of hospital admissions for children aged 1 to 9 years and 14% of admissions for children aged 10 to 17 years with SCD were followed by rehospitalization within 2 weeks of discharge,[18] which may reflect the receipt of suboptimal inpatient or follow-up care.

Measuring quality of care is a key step in improving outcomes: it has been endorsed by the Institute of Medicine as a primary aim for the US health care system.[19] Studies have shown that providing feedback to organizations about performance on quality measures can improve care.[20,21] Quality is often assessed using process-of-care measures, which address activities that should occur as part of the clinician-patient encounter (eg, vaccination, screening tests).[22] Better performance on process-of-care measures, as assessed by quality-of-care indicators, is associated with improved health outcomes. For example, better adherence to indicators of high quality care has been associated with decreased mortality in women with breast cancer[23] and high-risk elderly patients,[24] whereas lower adherence to indicators for inpatient care increases the risk of early hospital readmission for adults with chronic conditions.[25]

Currently, the assessment of quality of care for children with SCD across institutions is limited by a lack of quality measures developed for a comprehensive, interdisciplinary system of care. Although the American Academy of Pediatrics[1] and the National Heart, Lung, and Blood Institute[10] have provided some guidance in this area, their statements do not provide the level of specificity required for quality measurement and monitoring. The goal of this study was to develop a set of quality-of-care indicators for the management of children with SCD who are cared for in a variety of settings (eg, emergency department, outpatient clinics, inpatient wards), by addressing the broad spectrum of complications of their illness.

METHODS

Development of Draft Indicators

The research team systematically reviewed the scientific literature on the management of SCD in children. This review was submitted for publication separately. In brief, we searched the OVID Medline and Cochrane databases from January 1995 through April 2010, using terms related to 29 topics relevant to SCD in children 18 or younger: acute chest syndrome (ACS); aplastic crisis; asthma; avascular necrosis (AVN); cardiac care; cholelithiasis; comprehensive care; eye care; fever/sepsis; folic acid supplementation; genetic counseling; growth; hematopoietic stem cell transplant; hepatic sequestration; hydroxyurea treatment; immunization; leg ulcers; neuropsychological evaluation; osteomyelitis; pain; penicillin prophylaxis; priapism; pulmonary function testing; pulmonary hypertension; sickle cell nephropathy; splenic sequestration; stroke; TCD; and transfusion. We identified additional articles for inclusion by reviewing the bibliographies of key references. We screened 3187 abstracts and selected 320 articles for final review. Each article was reviewed by at least 2 investigators.

On the basis of our findings from the literature review, we drafted a set of candidate quality-of-care indicators and documented the highest level of supporting evidence for each indicator: (I) randomized controlled trial; (II)

TABLE 1 Sickle Cell Disease Expert Panel

Name	Professional Domain	Position and Affiliation
Robert Adams	Neurology	Professor of Neuroscience and Director of MUSC Stroke Center, Medical University of South Carolina (Charleston, SC)
Daniel Armstrong	Pediatric psychology	Professor of Pediatrics and Psychology and director of Sickle Cell Center, University of Miami, Miller School of Medicine (Miami, FL)
Samir K. Ballas	Pediatric and adult hematology	Emeritus professor of Medicine, Cardeza Foundation for Hematologic Research, Department of Medicine, Jefferson Medical College, Thomas Jefferson University (Philadelphia, PA)
George Buchanan	Pediatric hematology	Professor of Pediatrics and director, Pediatric Hematology-Oncology, University of Texas Southwestern Medical Center at Dallas and Children's Medical Center (Dallas, TX)
Lanetta Jordan	Public health practice; sickle cell disease in adolescents and adults	Director, Sickle Cell Services, Memorial Healthcare System (Hollywood, FL); chief medical officer, Sickle Cell Disease Association of America (Baltimore, MD)
Peter Lane	Pediatric hematology	Professor of Pediatrics, Emory University School of Medicine; director, Children's Healthcare of Atlanta Sickle Cell Disease Program (Atlanta, GA)
William Owen	Pediatric hematology	Associate professor of Pediatrics, Eastern Virginia Medical School; medical director, Comprehensive Sickle Cell Program, Children's Hospital of the King's Daughters (Norfolk, VA)
Elliott Vichinsky	Pediatric hematology	Director, Hematology/Oncology, Children's Hospital and Research Center Oakland (Oakland, CA); adjunct professor, University of California (San Francisco, CA)

nonrandomized controlled trial, cohort or case-control study, or multiple time series; or (III) descriptive study or expert opinion.[26] An indicator was included if it (1) measured an intervention or a treatment with potential health benefits for the patient, (2) was supported by adequate scientific evidence or professional consensus, (3) covered care that is under the control or influence of the health care provider or organization, and (4) covered information that typically is found in the medical chart or whose absence from the chart could be considered a marker for poor quality.[27]

Expert Panel

A modified Delphi method was used to generate the final set of indicators.[28] This process consists of 1 round of anonymous ratings of the indicators by an expert panel, a face-to-face panel discussion, and a second round of anonymous ratings immediately after the discussion. This method has been shown to produce appropriateness criteria for medical procedures and quality-of-care indicators that have face, construct, and predictive validity.[29–31]

We requested nominations for the expert panel from the National Heart, Lung, and Blood Institute, the American Academy of Pediatrics Section on Hematology/Oncology, the American Society of Hematology, the American Society of Pediatric Hematology/Oncology and the Sickle Cell Disease Association of America. In reviewing the nominations, we considered the experts' geographic locations in the United States and subspecialties to ensure that the panel represented a wide spectrum of clinical experience in the care of children with SCD. There was significant overlap in the nominations received; therefore, we used our literature review to augment the list of potential panelists by identifying individuals who had made unique contributions to the field. We then contacted the selected nominees to assess their interest and availability. Eight panelists participated (all except 1 nominee), including 5 hematologists (4 pediatric, 1 adult), 1 neurologist, 1 pediatric psychologist, and 1 psychiatrist/public health practitioner (Table 1).

For the first-round ratings, panelists were sent the list of candidate indicators along with the highest level of supporting evidence for each indicator and the relevant citations to the literature. Panelists rated each indicator separately for validity and for feasibility on a 9-point scale (1, lowest; 9, highest) before the face-to-face meeting. The panel was instructed to give high validity scores to indicators for which a high proportion of the determinants of adherence are under the clinician's or health plan's influence and at least 1 of the following criteria were met: (1) the supporting scientific evidence or professional consensus is adequate; (2) there are identifiable health benefits for patients who receive the specified care; or (3) clinicians or health plans with higher rates of adherence would be considered higher quality providers. A high feasibility score was given if (1) the average medical chart is likely to contain information that is needed to determine adherence, (2) estimates of adherence on the basis of medical chart data are likely to be reliable, and (3) failure to document information relevant to the indicator is itself a marker of poor quality.[27] Panelists also were encouraged to provide comments and suggest revisions to the candidate indicators.

The panel met at the Boston University Medical Center on November 23 and 24, 2009. At the start of the meeting, each panelist received a list of the candidate indicators that included his or her first round ratings for each indicator and the median first round ratings for the group. The research team was

present to answer questions about the literature review, the candidate indicators and the expert-panel process. Each candidate indicator was discussed during the meeting. Some were eliminated by consensus, others were modified, and new indicators were added. The panelists then completed anonymous ratings for the revised set of indicators during the second round.

In addition to rating the indicators on validity and feasibility, the panel expressed a desire to identify a subset of indicators to prioritize quality-improvement efforts. The panel rated the importance of each indicator on a 9-point scale (1, lowest; 9, highest), with high scores assigned to indicators that were likely to have a large positive impact on improving quality of life and/or health outcomes for children with SCD. After the meeting, the research team sent each panelist his or her first-round importance ratings and the median group ratings. The panelists then completed second-round importance ratings for each indicator. This study was considered exempt from review by the Boston University Medical Campus institutional review board.

Analysis of Ratings

We used the following scoring criteria to evaluate the panel ratings: indicators were accepted if they received a median validity score of 7 or higher and a median feasibility score of 4 or higher. Of those that met the cutoffs for median validity and feasibility, indicators were eliminated if substantial disagreement existed on either validity or feasibility (at least 3 votes in the 1–3 range and at least 3 votes in the 7–9 range for an 8- to 10-member panel).[32,33] These cutoffs were based on predetermined ranges and distribution of scores used in the Rand/University of California Los Angeles (UCLA) appropriateness method, a modified Delphi method developed at Rand and UCLA.[27,34] For the indicators that met the criteria for acceptance, importance ratings were used to identify indicators of highest priority (importance score $>$ 8).

The research team also analyzed the final set of indicators according to type of care (routine health care maintenance [RHCM], acute/subacute, or chronic), function of care (education, screening, diagnosis, treatment, or follow-up), and modality of care (history, physical examination, tests/evaluations, interventions, or returns and referrals). RHCM indicators include primary interventions such as immunizations. Acute and subacute care indicators relate to the spectrum of care for conditions that have a time-limited course. Chronic care indicators apply to conditions that last 3 months or more and cause significant morbidity.[27]

RESULTS

For the first round, 81 candidate indicators were drafted in 24 topics: ACS; asthma; AVN; cardiac care; cholelithiasis; eye care; fever/sepsis; folic acid supplementation; genetic counseling; growth; hematopoietic stem cell transplant; hydroxyurea treatment; immunization; neuropsychological evaluation; osteomyelitis; pain; penicillin prophylaxis; priapism; pulmonary function testing; pulmonary hypertension; stroke; TCD; transfusion; and transition to adult care. For some topics included in the literature review, the study team was not able to develop candidate indicators that met the inclusion criteria for indicator development[27] on the basis of the available evidence.

During the meeting, the panel eliminated 28 candidate indicators by consensus and made significant or minor changes to 32 indicators. Seven candidate indicators were each divided into 2 parts and rated as separate indicators. The panel also developed 2 new indicators during the discussion. Therefore, a total of 62 indicators were rated during the second round. Of the 62, 21 were eliminated (20 for low validity and 1 for substantial disagreement about validity), and 41 were retained in the final set.

The final 41 indicators cover 18 topics. Indicators for 5 original topics (cholelithiasis, eye care, folic acid supplementation, osteomyelitis, and pulmonary hypertension) were not included in the final set because of low ratings. The indicators for neuropsychological evaluation, stroke, and TCD were combined into 1 category (stroke) for simplicity. The indicator about pulmonary function testing was recategorized under ACS. We also added 2 categories, comprehensive planning and preoperative management, to better describe indicators that were changed significantly by the panel.

Tables 2, 3, and 4 list the 41 indicators according to type of care: 17 relate to RHCM (Table 2); 15 relate to acute or subacute care (Table 3); and 9 relate to chronic care (Table 4). The 17 RHCM indicators covered 10 different topics. One indicator addressed screening for asthma (indicator 1), 2 described comprehensive planning (indicators 2–3), 2 pertained to genetic counseling for parents of children with SCD (indicators 4–5), and 1 recommended longitudinal assessment of growth (indicator 6). Three indicators addressed immunizations for pneumococcal disease and influenza (indicators 7–9), 2 addressed penicillin prophylaxis (indicators 10–11), and 1 recommended education about priapism (indicator 12). Two pertained to stroke, including TCD screening (indicator 13) and neuropsychological evaluation (indicator 14). Of the remaining 3 indicators, 1 addressed transfusion (indicator 15),

TABLE 2 RHCM Indicators According to Topic

Indicator	Topic	Indicator Definition	Function[a]	Modality[b]	Strength of Evidence[c,26]	Importance Rating
1	Asthma	All children with SCD should be screened for asthma by history	S	H	II[48,49]	5.5
2[d]	Comprehensive planning	All children with SCD should have a comprehensive evaluation, including a pulse oximetry reading, CBC, and reticulocyte count documented at least annually	S	T	III[10]	8.5
3	Comprehensive planning	Parents of children with SCD should be given a written plan for access to care during an acute complication or illness (eg, fever, pain, etc)	E	R	III[50]	7.5
4	Genetic counseling	All children with a newborn screen indicative of SCD should have confirmatory testing documented by 2 mo of age	F	T	III[10,51]	8
5	Genetic counseling	All parents of children with SCD should be offered genetic counseling about SCD within 6 mo of the child's diagnosis	F	R	III[10,52]	7
6	Growth	Age-appropriate growth curves should be used for longitudinal assessment of growth of children with SCD for early detection of growth problems	S	Ph	II[53,54]	6.5
7	Immunization	Children with SCD should complete PCV7 vaccinations per CDC guidelines	Tr	I	II[9,55]	8
8	Immunization	Children and adolescents with SCD should complete PPV23 vaccinations per CDC guidelines	Tr	I	II[55,56]	8
9	Immunization	Children with SCD should have an annual influenza immunization according to CDC guidelines	Tr	I	III[10,57]	8
10[d]	Penicillin prophylaxis	All children with FS on initial newborn screen should receive antibiotic (eg, penicillin) prophylaxis by 2 mo of age	Tr	I	III[10,58]	9
11	Penicillin prophylaxis	Children with sickle cell anemia who are younger than 5 y should receive antibiotic (eg, penicillin) prophylaxis for pneumococcal disease	Tr	I	I[8,59]	8
12	Priapism	Education about priapism and its treatment options should be provided to parents and their male children with SCD by age 5; education should be documented in the chart	E	I	III[10,60]	6
13	Stroke	Children with SCD who are 2 y or older should be screened yearly with TCD and placed on a chronic transfusion program if found to have increased time-averaged maximal mean velocity (TAMMv) per the STOP study (≥200 cm/s)	S, Tr	T, I	I[11,13]	8
14	Stroke	All children with SCD should be screened annually using a parent-reported measure of adaptive functioning	S	H	II[61,62]	7.5
15	Transfusion	All children with SCD should have an extended RBC antigen phenotype documented	D	T	III[63,64]	8
16[d]	Transition to adult care	A transition plan to adult care, which includes a written transfer summary of the medical history, should be developed for pediatric patients with SCD	F	R	III[10]	8.5
17[d]	Transition to adult care	Adolescents with SCD should be counseled regarding the transition to adult providers, and counseling should be documented	E	R	III[10]	8.5

CBC indicates complete blood cell count; CDC, Centers for Disease Control and Prevention.

[a] Function: S indicates screening; E, education; D, diagnosis; Tr, treatment; F, follow-up.

[b] Modality: H indicates history; Ph, physical examination; T, tests; I, intervention/medication; R, return/referrals.

[c] Strength of evidence: I indicates randomized controlled trial; II, nonrandomized controlled trial, cohort or case control study, or multiple time series; III, descriptive study or expert opinion.

[d] Indicator rated higher than 8 for importance.

and 2 addressed planning for the transition from pediatric to adult care (indicators 16–17) (Table 2).

The 15 acute/subacute indicators covered 7 topics. Three were related to ACS (indicators 18–20), and 2 were related to AVN (indicators 21–22). Two indicators addressed the approach to managing fever (indicators 23–24). Two provided recommendations about acute pain care (indicators 25–26), and 1 addressed general preoperative management (indicator 27). Four indicators were related to stroke, including neuropsychological evaluation and TCD (indicators 28–31); 1 was related to transfusion for treatment of stroke (indicator 32) (Table 3).

The chronic care subset included 1 indicator on asthma (indicator 33), 1 on cardiac care (indicator 34), 2 on hematopoietic stem cell transplant (indicators 35–36), 1 on hydroxyurea (indicator 37), and 1 on stroke (indicator 38). The

TABLE 3 Acute/Subacute Indicators According to Topic

Indicator	Topic	Indicator Definition	Function[a]	Modality[b]	Strength of Evidence[c,26]	Importance Rating
18	ACS	All children with SCD and ACS should be treated with broad-spectrum antibiotics, including 1 from the macrolide class	Tr	I	III[65,66]	8
19	ACS	Children hospitalized for ACS should be evaluated for bronchoreactive lung disease	D	Ph	II[48]	5
20	ACS	All children with SCD hospitalized for acute pain requiring opioids should have documented incentive spirometry[e] with 10 maximal inspirations ≥2 h, a minimum of 6 times per day	D	T	I[67]	8
21	AVN	Children with early stage AVN (stage I–III) should have an orthopedic surgery consultation and a physical therapy evaluation	F	R	III[68,69]	6
22	AVN/preoperative management	Unless clinically contraindicated, a hemoglobin concentration between 9 and 11 g/dL should be obtained before elective orthopedic surgery	Tr	I	I[70]	5.5
23[d]	Fever	Children with SCD who have a fever of ≥38.5°C should be given parenteral broad spectrum antibiotic treatment within 60 min of triage	Tr	I	III[71]	9
24	Fever	For children with SCD who present with fever or history of fever (≥38.5°C), a CBC, reticulocyte count, and blood culture should be obtained	D	T	III[72]	7.5
25[d]	Pain	Children with SCD who present with an acute pain episode should receive a parenteral analgesic within 60 min of registration or 30 min of triage	Tr	I	III[10,50]	9
26[d]	Pain	Initial pain assessment should be documented using an age-appropriate pain scale, and the assessment should be repeated within 30 min of the first dose of analgesic	D	H	III[10,50]	9
27	Preoperative management	A multidisciplinary (eg, anesthesia, surgery, hematology) preoperative management plan should be documented for each child with SCD undergoing surgery	Tr	I	III[10,70]	8
28	Stroke	Patients with SCD with abnormal (lower than or at the standard score of 80) adaptive functioning based on parent report should undergo formal neurocognitive testing and neuroimaging	F	T	II[61,62]	7
29	Stroke	For children with SCD who have a conditional screen on TCD (TAMMv ≥170 and <200 cm/s), a second TCD should be performed within 3 mo	F	T	II[73,74]	7
30	Stroke	For children with SCD who have an abnormal screen on TCD (TAMMv ≥200 cm/s), the TCD result should be confirmed and a chronic transfusion program should be started within 1 mo of the initial abnormal TCD screen	F	T, I	I[11,13]	7.5
31	Stroke	Children who experience a stroke, silent infarct or TCD ≥170 should have an age-appropriate neurocognitive evaluation by a psychologist	F	R	II[61,75]	8
32	Stroke/transfusion	Children with SCD presenting with first time clinical stroke should be transfused	Tr	I	III[76]	8

CBC indicates complete blood cell count.
[a] Function: S indicates screening; E, education; D, diagnosis; Tr, treatment; F, follow-up.
[b] Modality: H indicates history; Ph, physical examination; T, tests; I, intervention/medication; R, return/referrals.
[c] Strength of evidence: I indicates randomized controlled trial; II, nonrandomized controlled trial, cohort or case control study, or multiple time series; III, descriptive study or expert opinion.
[d] Indicator rated higher than 8 for importance.
[e] Equivalent activities for young children.

list also included specific measures to be taken for children receiving chronic transfusions (indicators 39–41) (Table 4).

A subset of 8 indicators received median importance ratings of higher than 8 (on a 9-point scale). These indicators are identified in Tables 2 to 4 with a "d." Four of the indicators addressed RHCM, 3 addressed acute or subacute care, and 1 addressed chronic care. Six topics were represented: comprehensive planning (indicator 2); penicillin prophylaxis (indicator 10); transition to adult care (indicators 16–17); fever (indicator 23); pain (indicators 25–26); and transfusion (indicator 39). (Tables 2–4).

DISCUSSION

Children with SCD are at risk for many acute and long-term complications,[1,4] which can lead to early mortality.[7] Despite evidence of gaps and variations in quality,[15,17,18] efforts to assess and improve quality of care for children with SCD have been limited compared

TABLE 4 Chronic Indicators According to Topic

Indicator	Topic	Indicator Definition	Function[a]	Modality[b]	Strength of Evidence[c,26]	Importance Rating
33	Asthma	Children with SCD and asthma should have a written asthma plan	F	R	I[77]	7
34	Cardiac care	Children with SCD with blood pressure values above the 95th percentile for age should be evaluated and treated with antihypertensives	Tr	I	II[78]	6
35	Hematopoietic stem cell transplant	Children with sickle cell anemia younger than 16 without significant end organ dysfunction should be counseled about hematopoietic stem cell transplantation as a curative intervention	E	R	III	6
36	Hematopoietic stem cell transplant	Families of children with sickle cell anemia younger than 16 with a history of stroke, recurrent acute chest syndrome, or recurrent painful crises, should be offered the option of a hematopoietic stem cell transplant	Tr	I	II[79–81]	7.5
37	Hydroxyurea[e]	Hydroxyurea should be recommended for children 5 or older with recurrent painful episodes or ACS, and the recommendation should be documented	Tr	I	I[82]	8
38	Stroke	Children with SCD with a confirmed clinical stroke should be started on a chronic transfusion program with the goal of maintaining HbS levels <30% to prevent recurrent stroke	Tr	I	II[83]	8
39[d]	Transfusion	Children with SCD should be transfused with a minimum of ABO, C, D, E, and Kell-matched red cells	Tr	I	III[63,64]	8.5
40	Transfusion	Children with SCD who are 2 or older who are receiving a chronic transfusion program should have a comprehensive annual screening assessment for iron overload	S	T	III[10]	8
41	Transfusion	Children with SCD receiving a chronic transfusion program should receive chelation therapy to maintain ferritin <1500 or liver iron <7 mg/g dry weight by biopsy or MRI	Tr	I	II[84–86]	8

[a] Function: S indicates screening; E, education; D, diagnosis; Tr, treatment; F, follow-up.
[b] Modality: H indicates history; Ph, physical examination; T, tests; I, intervention/medication; R, return/referrals.
[c] Strength of evidence: I indicates randomized controlled trial; II, nonrandomized controlled trial, cohort or case control study, or multiple time series; III, descriptive study or expert opinion.
[d] Indicator rated higher than 8 for importance.
[e] Since the panel meeting, findings from the BABY HUG study on the use of hydroxyurea in children younger than 5 have been released.[87] This indicator should be re-evaluated as more evidence becomes available.

with other chronic childhood conditions,[27] including cystic fibrosis.[15,35,36] In this article, we have described the development of quality-of-care indicators for the management of SCD in children. This process involved a systematic review of the literature to create evidence tables for different treatment modalities, and 2 rounds of anonymous ratings by an expert panel, with a face-to-face meeting of panel members between rounds. The final set of 41 quality indicators can serve as a starting point for quality assessment and monitoring of care for children with SCD.

The panel aimed to develop a focused, usable set of indicators that emphasized the most relevant issues in pediatric SCD care; their commitment to this goal was demonstrated by the addition of a rating category for "importance" during the discussion. These importance ratings were included to prioritize the indicators developed by the panel. It should be noted that the 2 indicators that specified the need for rapid assessment and treatment of pain received the highest importance scores, which reflects the panel's emphasis on the function and quality of life for children with SCD. The panel also rated both indicators about the transition to adult care highly in the importance category. A smooth transition was considered a particularly important goal for adolescents with SCD because the risk of mortality from SCD seems to be elevated during this period.[7,37] Other topics with median importance ratings > 8 included comprehensive planning, treatment for fever, penicillin prophylaxis, and transfusion therapy.

In developing the indicators, the panel made some trade-offs by weighing the short-term and long-term benefits and risks of specific treatments. For example, when considering quality indicators for transfusion, the benefits for transfusion to prevent stroke in children must be balanced with the long-term risks associated with iron overload. With many indicators, the panel also chose to create less stringent statements in recommending care. For example, in indicators with specific time frames for interventions, the panelists sometimes chose a longer time frame than they wished because they feared too short of a time frame would be perceived as unrealistic, and many institutions would not even attempt to adhere to these indicators.

There are some limitations to this study. Although the indicators cover a

wide variety of topics, the final list did not include all those addressed in the original candidate indicators. This was partially because of a lack of adequate supporting evidence on a number of topics, but it also reflects the panel's desire to focus on topics that contribute to major complications of pediatric SCD. In addition, only 17% of the indicators were based on level I evidence (randomized controlled trials), 32% were level II (nonrandomized control trials; cohort or case-control studies), and 51% were level III (ie, on the basis of descriptive studies or expert opinion). The distribution of evidence levels is consistent with a previous Rand study to develop other quality indicators for children, where the majority (72%) were based on level III evidence.[27] Indicators should be based on the strongest scientific evidence available (eg, randomized controlled trials).[38,39] Yet, many areas of health care have a limited evidence base, and indicator development should not be restricted to topics with strong scientific evidence. Therefore, systematic strategies,[40–42] including the Rand/UCLA appropriateness method,[43] have been used to combine research with expert opinion when stronger evidence is lacking. The Rand/UCLA appropriateness method has been shown to produce appropriateness criteria for medical procedures and quality-of-care indicators that have face, construct, and predictive validity.[29–31]

Another potential limitation is the lack of concrete evidence to link the process measures included in this set of indicators to improved outcomes for children with SCD. However, this issue is not unique to our project. In only a handful of published articles has the process-outcome link been addressed, and most have been observational studies; it would not be possible to randomize individuals to good and bad care. Existing studies have revealed that better performance on process quality measures is strongly associated with better survival among community-dwelling vulnerable adults,[24] and 100% adherence to a set of quality indicators is significantly associated with better overall survival for patients with breast cancer.[23] However, acute care processes for stroke were not associated with functional outcome at 12 months,[44] and mixed results have been reported on the relationship between HbA1c levels and mortality.[45–47] These studies highlight the difficulty and complexity in selecting appropriate processes to measure and the need for additional studies to examine the process-outcome relationship further, especially in children.

CONCLUSIONS

Despite the limitations, the quality indicators presented here represent the synthesis of current evidence on existing interventions, which was vetted through an expert-panel process. The current set of indicators can serve as a starting set of quality indicators. As stronger clinical evidence becomes available, our initial set of indicators may yield to revisions that are based on new evidence. In the meantime, we can use this set of quality indicators to inform directions for future clinical trials that aim to improve care for children with SCD, examine and understand important factors that contribute to adherence to recommended care, and suggest opportunities for quality improvement and policy interventions.

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