RESEARCH ARTICLE

Trends and Variation in Care and Outcomes for Children Hospitalized With Acute Gastroenteritis

Aleisha M. Nabower, MD,[a] Matt Hall, PhD,[b] Jason Burrows, MD,[a] Amanda Dave, MD,[a] Ashley Deschamp, MD, MS,[a] Chinenye R. Dike, MD,[a] Joshua C. Euteneuer, MD,[a] Teri Mauch, MD, PhD,[a] Russell McCulloh, MD,[a] Laura Ortmann, MD,[a] Kari Simonsen, MD,[a] Gwenn Skar, MD,[a] Jessica Snowden, MD,[c] Veronica Taylor, MD, MS,[a] Jessica L. Markham, MD, MSc[d]

A B S T R A C T

OBJECTIVES: Assess trends in inpatient acute gastroenteritis (AGE) management across children's hospitals and identify elements of AGE management associated with resource use.

METHODS: We examined inpatient stays for children 6 months to 18 years hospitalized with AGE from 2009 to 2018 using the Pediatric Health Information System database. We characterized demographics, hospital-level resource use (ie, medications, laboratories, and imaging), and outcomes (ie, cost per case, 14-day revisit rates, and length of stay [LOS]). We compared demographic characteristics and resource use between 2009 to 2013 and 2014 to 2018 using χ^2 and Wilcoxon rank-sum tests. We grouped hospitals on the basis of 2009 use of each resource and trended use over time using logistic regression. Annual change in mean cost and LOS were estimated by using models of log-transformed data.

RESULTS: Across 32 354 hospitalizations at 38 hospitals, there was a high use of electrolyte testing (85.4%) and intravenous fluids (84.1%) without substantial changes over time. There were significant reductions in the majority of laboratory, medication, and imaging resources across hospitals over the study period. The most notable reductions were for rotavirus and stool testing. Many hospitals saw a decrease in LOS, with only 3 noting an increased revisit rate. Reductions in cost per case over time were most associated with decreases in imaging, laboratory testing, and LOS.

CONCLUSIONS: Significant variation in resource use for children hospitalized with AGE coupled with high use of resources discouraged in AGE guidelines highlights potential opportunities to improve resource use that may be addressed in future AGE guidelines and quality improvement initiatives.

[a]Department of Pediatrics, University of Nebraska Medical Center and Children's Hospital and Medical Center, Omaha, Nebraska; [b]Children's Hospital Association, Lenexa, Kansas; [c]Department of Pediatrics, University of Arkansas for Medical Sciences, Little Rock, Arkansas; and [d]Department of Pediatrics, Children's Mercy Kansas City and School of Medicine, University of Missouri–Kansas City, Kansas City, Missouri

Introduction of the rotavirus vaccine in 2006 decreased gastroenteritis-related hospitalizations in the United States and specifically reduced rotavirus hospitalization rates for all children (vaccinated and unvaccinated) between 2007 and 2011.[1,2] Despite this, gastroenteritis hospitalizations continue to require significant inpatient resources. From 2010 to 2011, ~4 in 1000 children were hospitalized for acute gastroenteritis (AGE), with an estimated direct cost of >$200 million annually.[2,3]

The Centers for Disease Control and Prevention (CDC) published management guidelines for AGE in 2003, which were endorsed by the American Academy of Pediatrics (AAP) in 2004. These guidelines emphasized the use of enteral rehydration except in cases of severe dehydration, discouraged the routine use of laboratory and imaging studies, and recommended against routine administration of antibiotics and antimotility agents.[4,5] The joint European Society for Pediatric Gastroenterology, Hepatology, and Nutrition (ESPGHAN) and European Society for Pediatric Infectious Disease guideline released in 2014 aligns with the AAP-endorsed CDC AGE guidelines in supporting enteral rehydration and judicious use of laboratory studies, imaging, and antibiotics. Although use of the CDC AGE guidelines in the outpatient settings is associated with decreased illness duration,[6] admission rates, and cost,[7] the extent to which these guidelines have influenced inpatient management is unclear. Tieder et al[8] found wide variation in the management of gastroenteritis with high use of nonrecommended management strategies, such as laboratory testing, among emergency department (ED) visits, and observation stays at children's hospitals from 2001 to 2006. They also showed that hospitals that were more adherent to CDC guidelines had lower costs for these patients.[8] However, this study was limited to patients <6 years of age and did not examine trends in management over time. Because other AAP clinical practice guidelines have taken several years to be associated with variable changes in disease-specific care,[9,10] the effects of the AAP-endorsed CDC recommendations likely were not fully represented in the Tieder et al[8] study.

Analyses examining the use of resources with regard to gastroenteritis management guidelines in children's hospitals in the post–rotavirus vaccine era may identify opportunities to improve future guideline implementation. Therefore, our objectives with the current study were to assess trends in gastroenteritis management in the inpatient setting over time and examine whether resource use was associated with hospital-level outcomes, including length of stay (LOS), cost per case, and 14-day revisits.

METHODS

Study Design and Data Source

We conducted a multicenter retrospective cohort study of the Pediatric Health Information System (PHIS), an administrative database of 52 children's hospitals in the United States affiliated with the Children's Hospital Association (Lenexa, KS). Thirty-eight hospitals were included in the current study, with 14 hospitals excluded for incomplete data during the study period. Patient data are deidentified within PHIS; however, encryption of patient identifiers allows for tracking of individual patients across visits. The PHIS database contains patient demographics; *International Classification of Diseases, Ninth Revision* (ICD-9), *Clinical Modification* and *International Classification of Diseases, 10th Revision* (ICD-10), *Clinical Modification* diagnoses and procedures; and daily billed resource use. Data quality and reliability are assured through the Children's Hospital Association and participating hospitals. This study was deemed nonhuman subjects research by the policies of the local institutional review board because of use of deidentified administrative data.

Study Population

We included inpatient and observation stays from 2009 to 2018 for children ages 60 days to 18 years with a principal diagnosis for gastroenteritis (ICD-9: 0088, 00861; ICD-10: A080, A084, A088) or a principal diagnosis of dehydration (ICD-9: 27651; ICD-10: E860) with a secondary diagnosis of gastroenteritis. We excluded transfers in from other hospitals because use data from the transferring hospital is not available in PHIS. To capture a generally healthy population of children with gastroenteritis, we also excluded children with complex chronic conditions,[11] those with an ICU stay, and those not discharged from the hospital. Complex chronic conditions are "any medical condition that can be reasonably expected to last at least 12 months (unless death intervenes) and to involve either several different organ systems or 1 system severely enough to require specialty pediatric care and probably some period of hospitalization in a tertiary care center."[12] Additionally, conditions that may necessitate expanded laboratory evaluation or treatment were excluded, including diabetes mellitus, diabetes insipidus, adrenal insufficiency, chronic kidney disease, short gut syndrome, heart failure, and hemolytic-uretic syndrome. Per guidelines, the presence of hypotension necessitates intravenous (IV) fluid replacement, and thus encounters with diagnostic codes for hypotension or shock were excluded. We excluded conditions that would impact the use of antibiotics, such as bacterial infections outside the gastrointestinal tract and immunocompromised states. Finally, conditions necessitating surgical procedures that require imaging, including appendicitis, intussusception, pyloric stenosis, obstruction, and perforation, were excluded (Supplemental Table 4).

Outcome Measures

We measured each hospital's annual use of resources as a percentage of encounters from billing data, including complete blood count, electrolytes, urinalysis or urine culture, rotavirus testing, stool studies (any laboratory study identified as a stool specimen), antibiotics, probiotics, IV fluids, antiemetics (ondansetron, chlorpromazine, prochlorperazine), computed tomography (CT), radiographs, and ultrasounds. Because of their low frequency of use, other antiemetics and MRI were not included. Additional measures included regionally adjusted cost per case (estimated from charges by using hospital and year-specific cost-to-charge ratios and inflated to

2018 dollars by using the medical component of the Consumer Price Index[13]), 14-day all-cause revisit rates (readmission or return to the ED), and LOS (measured in hours).

Demographics and Covariates

Demographics of the cohort included age (<1, 1–4, 5–9, 10–18 years), sex, race and ethnicity (non-Hispanic white, Non-Hispanic African American, Hispanic, Asian American, other), season, and payer (private, government, other).

Statistical Analysis

Continuous data were described with median and interquartile ranges (IQRs) because of nonnormal distribution. Categorical data were summarized with frequencies and percentages. Demographics and use were stratified by time periods (2009–2013 vs 2014–2018) and compared by using χ^2 and Wilcoxon rank-sum tests for categorical and continuous variables, respectively.

Hospitals were categorized into 3 groups on the basis of their 2009 use of each resource: low users (<25th percentile of hospitals), moderate users (25th–75th percentile), and high users (>75th percentile). Each hospital's use trends over time were assessed independently for each resource by using a logistic regression, with the binary dependent variable being whether each encounter received the specific resource and adjustments made for year, age, race, and payer. We also estimated the change in annual rates of readmission and return to the ED for each hospital using logistic regression. Finally, the change in mean annual cost per case and LOS for each hospital was estimated from modeled log-transformed data. All analyses were performed by hospital, and models were adjusted for changes in age, race, and payer. All analyses were performed with SAS v9.3 (SAS Institute, Inc, Cary, NC), and P values <.05 were considered statistically significant.

RESULTS
Overall Patient Population

We included 32 354 hospitalizations from 31 706 children with AGE during the study period (Fig 1, Table 1). Only 605 children had >1 hospitalization. The median number of admissions per hospital during the study period was 719 (IQR: 433–1077), representing a median of 0.38% (IQR: 0.29%–0.61%) of all hospitalizations. Overall, children 1 to 4 years of age were responsible for the greatest proportion of hospitalizations (46.9%) followed by infants <1 year of age (25.5%). The median LOS was 35 hours (IQR: 22–49), and the 14-day ED revisit rate was 7.7% (Table 2). The median cost per case was $3460 (IQR: $2422–$5066).

Across the 2 time periods (2009–2013 vs 2014–2018), there were significant changes in age (2 [IQR: 1–5] vs 2 [IQR: 0–5]), race (Hispanic: 17.1% vs 21.2%; non-Hispanic white: 54.9% vs 51.5%), payer (government: 50.4% vs 57.4%; private: 41.9% vs 38.4%; and other: 7.7% vs 4.2%; Table 1), 14-day revisit rate (7.1% vs 8.1%), and cost ($3564 vs

$3369). There was no change in LOS (Table 2).

Use Characteristics

In analyzing resource use across hospitals, we observed the highest use rates for electrolyte tests (85.4%), IV fluids (84.1%), and antiemetics (58.2%). The least frequently used resources were CT imaging (7%) and rotavirus testing (16.5%) (Table 2). There were significant reductions in the majority of laboratory, pharmacy, and imaging resource use between the 2 periods, with the greatest changes in rotavirus testing (25.4% vs 9.1%) and stool studies (42.3% vs 24.7%; all $P <$ .001). There was an increase in the use of antiemetics (54.4% vs 61.4%; $P <$ .001) (Table 2).

Hospital Performance

As seen from examining the trends in resource usage at a hospital level, the majority of hospitals showed decreased use
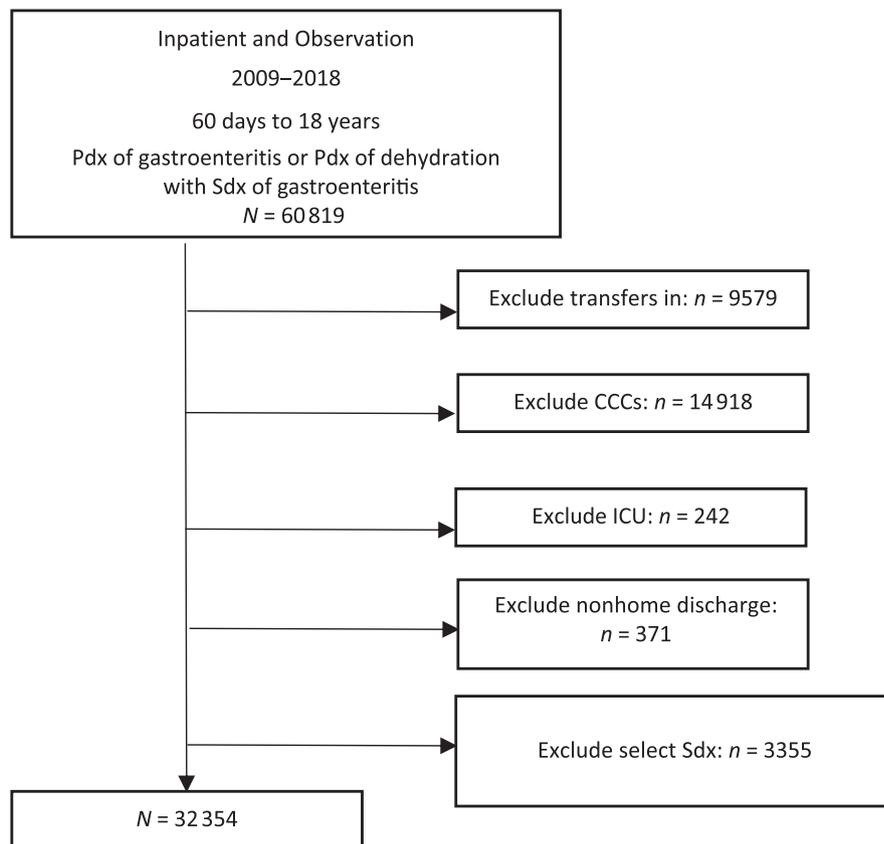
FIGURE 1   Cohort flowchart. CCC, complex chronic condition; Pdx, principal diagnosis; Sdx, secondary diagnosis.

TABLE 1 Demographic Characteristics of the Study Group

	Overall (N = 32 354), n (%)	2009–2013 (n = 14 785), n (%)	2014–2018 (n = 17 569), n (%)	P
Age, y				
<1	8245 (25.5)	3650 (24.7)	4595 (26.2)	<.001
1–4	15 162 (46.9)	7311 (49.4)	7851 (44.7)	—
5–9	5522 (17.1)	2444 (16.5)	3078 (17.5)	—
10–18	3425 (10.6)	1380 (9.3)	2045 (11.6)	—
Sex				
Male	16 811 (52.0)	7784 (52.6)	9027 (51.4)	.023
Female	15 543 (48.0)	7001 (47.4)	8542 (48.6)	—
Race and ethnicity				
Non-Hispanic white	17 180 (53.1)	8124 (54.9)	9056 (51.5)	<.001
Non-Hispanic African American	5369 (16.6)	2483 (16.8)	2886 (16.4)	—
Hispanic	6259 (19.3)	2530 (17.1)	3729 (21.2)	—
Asian American	868 (2.7)	338 (2.3)	530 (3.0)	—
Other	2678 (8.3)	1310 (8.9)	1368 (7.8)	—
Season				
Spring	10 582 (32.7)	5060 (34.2)	5522 (31.4)	<.001
Summer	5861 (18.1)	2602 (17.6)	3259 (18.5)	—
Fall	6441 (19.9)	2744 (18.6)	3697 (21.0)	—
Winter	9470 (29.3)	4379 (29.6)	5091 (29.0)	—
Payer				
Government	17 544 (54.2)	7456 (50.4)	10 088 (57.4)	<.001
Private	12 944 (40.0)	6197 (41.9)	6747 (38.4)	—
Other	1866 (5.8)	1132 (7.7)	734 (4.2)	—

—, not applicable.

of rotavirus testing (36 out of 38) and stool studies (35 out of 38) over time regardless of performance in 2009. Similarly, there was a decrease in antibiotic use in 16 out of 38 hospitals over the study period. There was wide variation in the use of probiotics, with 11 hospitals not using them at all and 17 hospitals showing unchanged usage over time. The use of antiemetics increased in 15 out of 38 of hospitals studied. Interestingly, 13 out of 15 hospitals reporting an increase were low or moderate users in 2009. IV fluids were commonly used in patients admitted for AGE, with only 15 out of 38 hospitals reporting a decrease in their usage over time. Although the use of CT and radiographs decreased in many hospitals, the use of ultrasounds increased across most hospitals (Fig 2).

Changes in Cost and LOS Over Time

In examining trends in hospital-level outcomes over time, we observed

reductions in LOS in 15 out of 38 hospitals, with only 3 hospitals showing an increase in 14-day revisit rates (Fig 1). There was a reduction in adjusted annual costs in 21 out of 38 hospitals and increased annual costs in 1 out of 38 hospitals. The cost savings among these hospitals ranged from $42 to $290 per case. Cost savings was most commonly associated with decreased LOS, although in ∼1 out of 4 hospitals it was also associated with decreased use of imaging or laboratory studies (Table 3).

DISCUSSION

In this multicenter retrospective study of children hospitalized with AGE, we observed varied resource use with regards to the CDC guidelines. A high percentage of patients received IV fluids, complete blood counts, and electrolyte testing across the majority of hospitals. Although we observed consistent reductions in rotavirus testing and stool studies over time, changes in other resource use were small and suggest

future opportunities for diagnostic and resource stewardship as well as cost savings. This is supported by our finding that reductions in resource use and LOS were associated with cost savings over time. Among resources not explicitly addressed in the CDC guidelines, including probiotics, imaging, and antiemetics, we observed wide variation in use that could also benefit from clarification and/or standardization in future guidelines.

Electrolyte testing was common across PHIS hospitals, with little reduction over the study period. This finding is at odds with both CDC and the ESPGHAN guidelines, which advise against supplementary laboratory studies including electrolytes,[4,5] representing a potential target for future interventions. The high use of laboratory testing found in our study is consistent with previous publications in which authors describe a trend of unnecessary laboratory tests in the evaluation and management of AGE and other common pediatric

TABLE 2 Resource Use Characteristics

	Overall ($N = 32\,354$)	2009–2013 ($n = 14\,785$)	2014–2018 ($n = 17\,569$)	P
Laboratory, _n_ (%)				
CBC	17 786 (55)	8284 (56)	9502 (54.1)	<.001
Electrolyte test	27 639 (85.4)	13 032 (88.1)	14 607 (83.1)	<.001
Urine culture	8257 (25.5)	4175 (28.2)	4082 (23.2)	<.001
Urinalysis	14 461 (44.7)	6884 (46.6)	7577 (43.1)	<.001
Rotavirus	5349 (16.5)	3748 (25.4)	1601 (9.1)	<.001
Stool studies	10 593 (32.7)	6258 (42.3)	4335 (24.7)	<.001
Pharmacy, _n_ (%)				
Antibiotics	4676 (14.5)	2400 (16.2)	2276 (13)	<.001
Probiotics	6837 (21.1)	3208 (21.7)	3629 (20.7)	.022
IV fluids	27 217 (84.1)	12 440 (84.1)	14 777 (84.1)	.940
Antiemetics[a]	18 838 (58.2)	8044 (54.4)	10 794 (61.4)	<.001
Imaging, _n_ (%)				
CT	2257 (7)	1147 (7.8)	1110 (6.3)	<.001
Radiograph	12 080 (37.3)	5815 (39.3)	6265 (35.7)	<.001
Ultrasound	7573 (23.4)	2751 (18.6)	4822 (27.4)	<.001
Clinical course				
Median LOS (IQR),h	35 (22–49)	35 (21–49)	34 (22–48)	.575
14-d revisit, _n_ (%)	2483 (7.7)	1054 (7.1)	1429 (8.1)	.001

CBC, complete blood cell count.

[a] Ondansetron, chlorpromazine, and prochlorperazine.

conditions.[10,14–16] Further studies are warranted to determine key drivers of electrolyte testing and appropriate clinical scenarios necessitating electrolyte testing.

In this cohort, 84% of patients received IV fluid, with no significant change in use over time. Current guidelines universally recommend enteral hydration as first-line therapy; however, failure of oral hydration or moderate to severe dehydration are indications for IV fluid and possible inpatient admission.[4,5] Whether the high rate of IV fluid use in our data set represents an overreliance on IV fluids or an appropriate application of CDC guidelin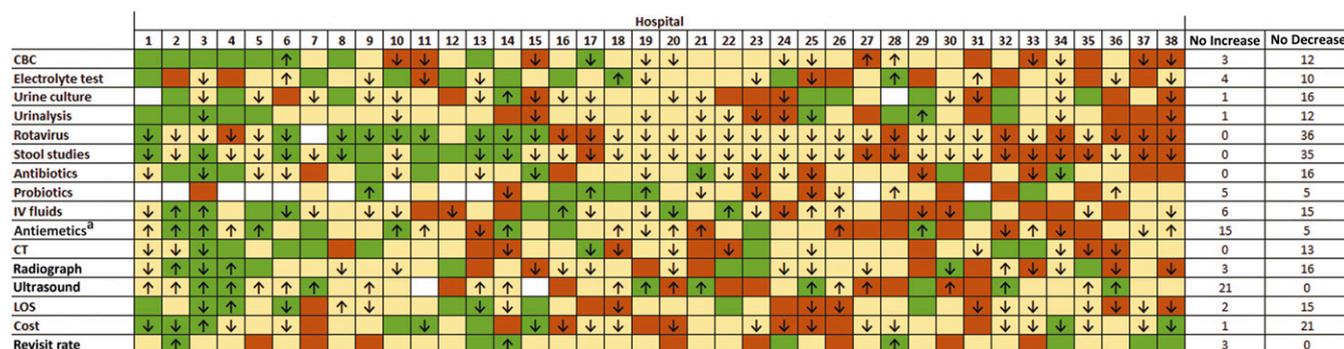es for hospitalized patients is unknown because we are unable to assess the failure of oral rehydration or severity of dehydration in this data set. Additionally, patient and family expectations for medical intervention may also play a role in IV fluid use, especially in resource-rich countries.[17] This possibility warrants further investigation because reducing IV fluid use in favor of oral rehydration could potentially result in significant cost savings and reduction in downstream laboratory testing.

We found that supplementary testing including infection evaluation (ie, urinalysis or urine cultures, rotavirus testing, and stool studies) decreased between the 2 time periods. Encouragingly, we observed reductions for rotavirus and stool study testing, consistent with guideline recommendations. Although it is certainly possible that the decrease in specific rotavirus testing was due to the emergence of microbial panel tests that included rotavirus, the corresponding decrease in all stool studies makes this less likely. Our observations of reduced infection testing therefore likely represent a combination of the introduction of the rotavirus vaccine and recommendations outlined in the CDC guidelines reserving obtainment of stool studies for cases of bloody diarrhea or diarrhea in immunocompromised patients.[4,5]

Despite several guidelines discouraging the empirical use of antimicrobial agents for AGE,[4,5] we observed that nearly 1 in

FIGURE 2 Heat map revealing the hospital-level change in resource use and clinical outcomes over time compared with other PHIS hospitals. Each column represents 1 PHIS site, and each row represents 1 resource. [a]Ondansetron, chlorpromazine, and prochlorperazine included. Sites are organized from lowest overall usage in 2009 to highest. CBC, complete blood cell count.

TABLE 3 Resource Reduction Related to Reduced Cost

ID	Annual Change in Adjusted Cost per Case in US Dollars (95% CI)	Resource Reduction Associated With Decreasing Cost			
		LOS	Imaging	Laboratory	Pharmacy
20	−290.0 (−337.5 to −242.5)	X	X	X	—
25	−263.6 (−306.0 to −221.2)	X	X	X	—
37	−229.8 (−332.5 to −127.0)	X	—	—	—
35	−212.2 (−264.0 to −160.4)	X	—	X	—
16	−209.5 (−297.8 to −121.2)	X	—	—	X
24	−197.9 (−246.9 to −149.0)	X	—	—	—
17	−157.7 (−188.8 to −126.7)	—	—	—	—
6	−137.3 (−181.0 to −93.6)	X	—	—	—
18	−130.4 (−186.9 to −73.9)	X	X	X	—
38	−114.4 (−133.0 to −95.8)	—	X	—	—
27	−114.1 (−168.5 to −59.8)	X	—	—	—
34	−96.6 (−118.8 to −74.5)	X	X	X	—
4	−92.6 (−119.0 to −66.3)	—	—	X	—
23	−92.2 (−133.8 to −50.7)	—	—	—	—
11	−92.0 (−130.3 to −53.7)	X	—	—	X
32	−79.8 (−105.1 to −54.6)	X	—	—	—
33	−73.7 (−95.6 to −51.9)	X	X	—	—
1	−70.6 (−86.3 to −54.9)	X	X	X	—
15	−63.7 (−94.2 to −33.2)	—	—	X	—
28	−51.5 (−87.7 to −15.3)	—	—	—	—
2	−41.9 (−59.6 to −24.1)	—	—	—	—

Annual change in adjusted cost per case based on logistic regression data. Variables significantly associated with decreased cost are denoted with an X ($P < .05$). CI, confidence interval; ID, identifier; —, not applicable.

5 children in our study were prescribed an antibiotic, despite accounting for diagnosed bacterial infections outside the gastrointestinal system. Multiple guidelines recommend limiting antibiotic use to specific pathogens and for defined clinical situations, including infants, immunocompromised hosts, and those with underlying disorders who are systemically ill.[4,5,18] Routine use of antimicrobial agents for treating diarrhea wastes resources, increases treatment cost, and can lead to increased antimicrobial resistance or prolonged diarrheal illness.[4,19] Although we observed small decreases in antibiotic use across several hospitals over time, our observations highlight an important antimicrobial stewardship opportunity.

Neither the CDC nor subsequent ESPGHAN guidelines recommend imaging in the evaluation of gastroenteritis.[4,5] Despite this fact, 84% of patients admitted with gastroenteritis underwent radiologic imaging, although we did see a shift away from studies requiring radiation exposure and toward ultrasound imaging over the 2 study periods. This transition is consistent with other research showing an increase in ultrasound use in hospitalized children.[20] For future guidelines, authors should seek to define the role of imaging in AGE (ie, inability to exclude appendicitis or intussusception) to optimize use of resources and control costs.

Currently, none of the published pediatric AGE guidelines address the use of probiotics in management. Wide variation in probiotic use was seen across centers and even within centers over time in our study. This highlights the knowledge gap in this area, and our results are likely reflective of providers' preferential practices. Probiotic use in pediatric AGE remains an area for further research because available studies have yielded conflicting results regarding its benefits.[19,21,22]

The use of antiemetics, most commonly ondansetron, increased over the study period. However, we were unable to assess what proportion represented use before admission. Ondansetron use has been shown in some studies to decrease admission rates and the need for IV rehydration[23] and therefore could be used appropriately as a single dose to avoid admission. Few data exist on the efficacy of continuing antiemetics in admitted patients with potential adverse events, including increased diarrhea[24] and dose-dependent QT prolongation.[25] As such, both the CDC and ESPGHAN guidelines recommended against their routine use until further data are available,[4,5] representing another potential point for clarification in future guidelines.

Our findings should be interpreted in the context of several limitations. First, the PHIS database is an administrative database and does not contain data pertaining to clinical decision-making surrounding diagnostic testing and resource use. Consequently, we are limited in our ability to evaluate the appropriateness of diagnostic testing, use of fluid resuscitation, and antimicrobial agents. Although we used a case identification strategy based on previously published literature,[14] the use of billing codes for creating our cohort could result in misclassification bias. Additionally, the use of certain resources, such as nasogastric rehydration, cannot be reliably captured within PHIS. Within PHIS, we are limited in our ability to examine how local protocols and policies influence testing patterns at individual institutions because these data are not collected. Although we accounted for factors such as age, sex, race, and payer in our analyses, unaccounted-for differences in patient characteristics could contribute to variation and observed differences in the relationship between test variation and hospitalization outcomes across groups. Additionally, we were unable to determine what interventions occurred in the ED setting as opposed to after admission. Finally, our analysis only includes data from freestanding children's hospitals, which may not be representative of other pediatric acute care and inpatient settings. It is crucial to also study these use patterns in nonchildren's hospitals because

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children in rural and other medically underserved areas frequently have limited access to dedicated pediatric care.[26]

Overall, we observed many instances of variation in pediatric AGE care. Although some of the observed variation may be warranted because of patient-level factors, a significant portion of the variation is likely to be unnecessary and may be mitigated by improved adherence to AGE guidelines.[27] Similar to findings in the study by Tieder et al[8] in the ED, we found that decreased resource use correlated with decreased cost for admitted patients, supporting the notion that adherence to guidelines not only represents high-quality care but also high-value care. Given the potentially modifiable nature of unwarranted variation, high-quality collaborative research is needed to support standard practices, optimize effective care, and inform future guideline development.

CONCLUSIONS

In this study, we expand on previous knowledge by examining trends in resource use in the inpatient management of pediatric AGE since the introduction of the rotavirus vaccine. Although decreased use of rotavirus testing, stool studies, and antimicrobial agents are to be commended, high use of resources not recommended in current guidelines, such as electrolyte testing and the use of IV fluids, persists. These findings underscore the need for future large-scale quality improvement initiatives to address these management practices. Additionally, the wide variation observed in the use of probiotics and antiemetics highlights an opportunity to more specifically address these medications within future AGE guidelines. Addressing unwarranted variation in care may lead to improvements in the quality and cost of care for children hospitalized with AGE.

REFERENCES

1. Parashar UD, Alexander JP, Glass RI; Advisory Committee on Immunization Practices (ACIP), Centers for Disease Control and Prevention (CDC). Prevention of rotavirus gastroenteritis among infants and children. Recommendations of the Advisory Committee on Immunization Practices (ACIP). *MMWR Recomm Rep.* 2006;55(RR-12):1–13

2. Leshem E, Moritz RE, Curns AT, et al. Rotavirus vaccines and health care utilization for diarrhea in the United States (2007-2011). *Pediatrics.* 2014; 134(1):15–23

3. Leshem E, Tate JE, Steiner CA, Curns AT, Lopman BA, Parashar UD. Acute gastroenteritis hospitalizations among US children following implementation of the rotavirus vaccine. *JAMA.* 2015; 313(22):2282–2284

4. King CK, Glass R, Bresee JS, Duggan C; Centers for Disease Control and Prevention. Managing acute gastroenteritis among children: oral rehydration, maintenance, and nutritional therapy. *MMWR Recomm Rep.* 2003;52(RR-16):1–16

5. Guarino A, Ashkenazi S, Gendrel D, Lo Vecchio A, Shamir R, Szajewska H; European Society for Pediatric Gastroenterology, Hepatology, and Nutrition; European Society for Pediatric Infectious Diseases. European Society for Pediatric Gastroenterology, Hepatology, and Nutrition/European Society for Pediatric Infectious Diseases evidence-based guidelines for the management of acute gastroenteritis in children in Europe: update 2014. *J Pediatr Gastroenterol Nutr.* 2014;59(1): 132–152

6. Albano F, Lo Vecchio A, Guarino A. The applicability and efficacy of guidelines for the management of acute gastroenteritis in outpatient children: a field-randomized trial on primary care pediatricians. *J Pediatr.* 2010;156(2): 226–230

7. Lind CH, Hall M, Arnold DH, et al. Variation in diagnostic testing and hospitalization rates in children with acute gastroenteritis. *Hosp Pediatr.* 2016;6(12):714–721

8. Tieder JS, Robertson A, Garrison MM. Pediatric hospital adherence to the standard of care for acute gastroenteritis. *Pediatrics.* 2009;124(6).

Available at: www.pediatrics.org/cgi/content/full/124/6/e1081

9. Coco A, Vernacchio L, Horst M, Anderson A. Management of acute otitis media after publication of the 2004 AAP and AAFP clinical practice guideline. *Pediatrics.* 2010;125(2):214–220

10. Parikh K, Hall M, Teach SJ. Bronchiolitis management before and after the AAP guidelines. *Pediatrics.* 2014;133(1). Available at: www.pediatrics.org/cgi/content/full/133/1/e1

11. Feudtner C, Feinstein JA, Zhong W, Hall M, Dai D. Pediatric complex chronic conditions classification system version 2: updated for ICD-10 and complex medical technology dependence and transplantation. *BMC Pediatr.* 2014;14: 199

12. Feudtner C, Hays RM, Haynes G, Geyer JR, Neff JM, Koepsell TD. Deaths attributed to pediatric complex chronic conditions: national trends and implications for supportive care services. *Pediatrics.* 2001;107(6). Available at: www.pediatrics.org/cgi/content/full/107/6/E99

13. US Bureau of Labor Statistics. Consumer price index. 2019. Available at: https://www.bls.gov/cpi/. Accessed September 10, 2019

14. Tchou MJ, Hall M, Shah SS, et al; Pediatric Research in Inpatient Settings (PRIS) Network. Patterns of electrolyte testing at children's hospitals for common inpatient diagnoses. *Pediatrics.* 2019;144(1):e20181644

15. Nager AL, Wang VJ. Comparison of nasogastric and intravenous methods of rehydration in pediatric patients with acute dehydration. *Pediatrics.* 2002; 109(4):566–572

16. Teach SJ, Yates EW, Feld LG. Laboratory predictors of fluid deficit in acutely dehydrated children. *Clin Pediatr (Phila).* 1997;36(7):395–400

17. Nir V, Nadir E, Schechter Y, Kline-Kremer A. Parents' attitudes toward oral rehydration therapy in children with mild-to-moderate dehydration.

ScientificWorldJournal. 2013;2013: 828157

18. Lo Vecchio A, Vandenplas Y, Benninga M, et al. An international consensus report on a new algorithm for the management of infant diarrhoea. *Acta Paediatr.* 2016; 105(8):e384–e389

19. Szajewska H, Hoekstra JH, Sandhu B; ESPGHAN Working Group on Acute Diarrhoea. Management of acute gastroenteritis in Europe and the impact of the new recommendations: a multicenter study. The working group on acute diarrhoea of the European society for paediatric Gastroenterology, Hepatology, and nutrition. *J Pediatr Gastroenterol Nutr.* 2000;30(5):522–527

20. Parker MW, Shah SS, Hall M, Fieldston ES, Coley BD, Morse RB. Computed tomography and shifts to alternate imaging modalities in hospitalized children. *Pediatrics.* 2015;136(3).

Available at: www.pediatrics.org/cgi/content/full/136/3/e573

21. Freedman SB, Vandermeer B, Milne A, Hartling L; Pediatric Emergency Research Canada Gastroenteritis Study Group. Diagnosing clinically significant dehydration in children with acute gastroenteritis using noninvasive methods: a meta-analysis. *J Pediatr.* 2015;166(4):908–916.e6

22. Schnadower D, Finkelstein Y, Freedman SB. Ondansetron and probiotics in the management of pediatric acute gastroenteritis in developed countries. *Curr Opin Gastroenterol.* 2015;31(1):1–6

23. Tomasik E, Ziółkowska E, Kołodziej M, Szajewska H. Systematic review with meta-analysis: Ondansetron for vomiting in children with acute gastroenteritis. *Aliment Pharmacol Ther.* 2016;44(5): 438–446

24. Fedorowicz Z, Jagannath VA, Carter B. Antiemetics for reducing vomiting related to acute gastroenteritis in children and adolescents. *Cochrane Database Syst Rev.* 2011;(9):CD005506

25. U.S. Food and Drug Administration. FDA drug safety communication: new information regarding QT prolongation with ondansetron (Zofran). Available at: https://www.fda.gov/drugs/drug-safety-and-availability/fda-drug-safety-communication-new-information-regarding-qt-prolongation-ondansetron-zofran#safety. Accessed October 30, 2020

26. Melzer SM, Grossman DC, Hart LG, Rosenblatt RA. Hospital services for rural children in Washington State. *Pediatrics.* 1997;99(2):196–203

27. Goodman DC. Unwarranted variation in pediatric medical care. *Pediatr Clin North Am.* 2009;56(4):745–755