Trends in Low-Value Care Among Children's Hospitals

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abstract

BACKGROUND AND OBJECTIVES: Longitudinal pediatric low-value care (LVC) trends are not well established. We used the Pediatric Health Information System LVC Calculator, which measures utilization of 30 nonevidenced-based services, to report 7-year LVC trends.

METHODS: This retrospective cohort study applied the LVC Calculator to emergency department (ED) and hospital encounters from January 1, 2016, to December 31, 2022. We used generalized estimating equation models accounting for hospital clustering to assess temporal changes in LVC.

RESULTS: There were 5 265 153 eligible ED encounters and 1 301 613 eligible hospitalizations. In 2022, of 21 LVC measures applicable to the ED cohort, the percentage of encounters with LVC had increased for 11 measures, decreased for 1, and remained unchanged for 9 as compared with 2016. Computed tomography for minor head injury had the largest increase (17%–23%; $P < .001$); bronchodilators for bronchiolitis decreased (22%–17%; $P = .001$). Of 26 hospitalization measures, LVC increased for 6 measures, decreased for 9, and was unchanged for 11. Inflammatory marker testing for pneumonia had the largest increase (23%–38%; $P = .003$); broad-spectrum antibiotic use for pneumonia had the largest decrease (60%–48%; $P < .001$). LVC remained unchanged or decreased for most medication and procedure measures, but remained unchanged or increased for most laboratory and imaging measures.

CONCLUSIONS: LVC improved for a minority of services between 2016 and 2022. Trends were more favorable for therapeutic (medications and procedures) than diagnostic measures (imaging and laboratory studies). These data may inform prioritization of deimplementation efforts.

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Dr House conceptualized and designed the study, reviewed and interpreted the data, drafted the initial manuscript, and iteratively reviewed and revised the manuscript; Drs Coon, Marin, Ralston, Ho, Reyes, and Schroeder conceptualized and designed the study, and critically reviewed and revised the manuscript; Dr Hall and Ms Gruhler De Souza participated in study design, conducted the data analytics and statistical analyses, and reviewed and revised the manuscript; and all authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

DOI: https://doi.org/10.1542/peds.2023-062492

Accepted for publication Oct 19, 2023

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PEDIATRICS (ISSN Numbers: Print, 0031-4005; Online, 1098-4275).

WHAT'S KNOWN ON THIS SUBJECT: Low-value care (LVC) is an established problem in the pediatric hospital setting, contributing to patient harms and unnecessary costs. Temporal trends in pediatric LVC are not yet well established.

WHAT THIS STUDY ADDS: Trends in hospital-based LVC varied by measure from 2016 to 2022; relatively few measures demonstrated performance improvement. Trends were more favorable for treatment measures (medications and imaging) than for diagnostic measures (imaging and laboratory studies) over this period.

To cite: House SA, Marin JR, Coon ER, et al. Trends in Low-Value Care Among Children's Hospitals. *Pediatrics.* 2024;153(1):e2023062492

Low-value care (LVC), the delivery of health care services for which the likely benefits do not outweigh potential risks or costs, has been identified as an important problem in pediatric health care.[1–7] LVC results in both direct patient harm[8–11] and unnecessary costs[4,12,13]; thus, the reduction of wasteful services should be a central area of focus for efforts to improve health care value. Hospital-based LVC, including care delivered in the emergency department (ED) and inpatient settings, warrants particular attention. Hospital-based care is increasingly costly[14]; in pediatrics, this care is estimated to account for >40% of the $300 billion spent on child health,[15,16] and this higher acuity population may be particularly prone to receiving services for which evidence of effectiveness is lacking.

To improve understanding of hospital-based LVC delivery, our research group developed the Pediatric Health Information System (PHIS) LVC Calculator, a tool measuring the proportion and volume of ED and hospital encounters in which 30 nonevidence-based services (imaging and laboratory studies, procedures, and medications) are delivered. Previous application of this tool to eligible encounters from 49 hospitals in 2019 found that some low-value services were delivered in up to 60% of encounters; in total, these services were associated with nearly $17 million in standardized costs over this single calendar year.[3]

Although a growing body of literature describes the impact of LVC in the hospital setting,[1–3,5,6] most analyses are cross-sectional, describing utilization of services at a single time point[1,3,5,6]; data describing longitudinal trends in pediatric LVC delivery are limited to a small number of conditions and services. For example, LVC in viral bronchiolitis has decreased markedly over the past decade in both the inpatient and ED settings,[2,17–19] and existing evidence supports a decrease in prolonged intravenous antibiotics for osteomyelitis.[20,21] In contrast, inflammatory marker testing in community-acquired pneumonia (CAP) has not improved over the past decade.[3,22] Consistent measurement of pediatric hospital-based LVC delivery across conditions and services will help guide prioritization of limited deimplementation resources and assess sustainability of improvements.

Maintaining an awareness of temporal trends in pediatric LVC delivery has been challenged by lack of data infrastructure with this capability. The LVC Calculator was designed to facilitate such longitudinal assessment of low-value service delivery. In this study, our objective was to evaluate temporal trends in LVC delivery for 30 services from 2016 to 2022 using this tool.

METHODS

Data Source

PHIS is an administrative database containing deidentified data with demographics, diagnoses, procedures, and daily billing information from 49 children's hospitals. Participating hospitals are large children's hospitals located in urban regions in 27 states and the District of Columbia. Data quality is ensured through a joint effort between the Children's Hospital Association (Lenexa, Kansas) and participating hospitals.

Low-Value Care Calculator

Detailed methodology of the LVC Calculator's development and full measure specifications were previously published.[3] Briefly, the tool contains 30 LVC measures applicable to 2 patient cohorts:

1. ED cohort, defined as encounters resulting in discharge from the ED; and
2. Hospitalized cohort, defined as encounters for patients admitted to the hospital under inpatient or observation status.

In the hospitalized cohort, measured care includes that delivered as an inpatient and during the associated ED visit, because PHIS cannot distinguish between the 2 settings within the same facility. Some LVC measures are applicable to both cohorts, whereas others are appropriate for application in only 1.

Measures included in the LVC Calculator represent the delivery of medications, laboratory and imaging studies, and procedures delivered during clinical scenarios in which the evidence does not support their use. Measures were derived from quality measure and recommendation sets published by national organizations, or as part of previous research efforts.[4,23–26] The multidisciplinary stakeholder group responsible for the calculator's development prioritized narrow measure definitions.[3] This approach was intended to define LVC with high specificity, while minimizing misclassification of appropriate, or justified, care practices.[3,4] To do this, the LVC Calculator first applies a set of global exclusions to remove encounters with a high level of patient complexity or very severe illness. The tool then employs measure-specific exclusions to remove encounters with evidence of justification for a particular service.[3] Measure definitions are shown in Supplemental Table 4.

The LVC Calculator is designed as both a research and quality improvement tool. It is used to measure characteristics of LVC delivery across PHIS hospitals; additionally, clinicians at participating hospitals can access data describing local LVC delivery patterns at any time and compare performance to peer hospitals.

Study Design

We conducted a retrospective cohort study by applying the LVC Calculator to encounters between January 1, 2016, and December 31, 2022. Because measures were defined using International Classification of Diseases, 10th Revision, Clinical Modification, codes, 2016 was the first full year to which the LVC Calculator could be

applied. Hospitals not contributing data for the entire study period were excluded.

Encounters were included for analysis if they met criteria for ≥1 of the LVC Calculator measures. Per the calculator's parameters, encounters for patients aged >18 years and those with International Classification of Diseases, 10th Revision, codes indicating complex chronic conditions[27] or neurologic impairment[28] were excluded. Encounters with All Patient Refined Diagnosis-Related Groups (3M Healthcare) for extreme severity of illness and those with intensive care utilization (with the exception of neonatal intensive care-specific measures) were also excluded from the hospitalized cohort. Measure-specific exclusions were then applied to remove encounters with justification of low-value service delivery.[3] Encounters lacking any of the above exclusion criteria served as the denominator for LVC analyses.

Outcome Measures and Statistical Analysis

For all included measures, we calculated percentage of LVC delivery by year, defined as the number of eligible encounters with LVC (numerator) divided by the total number of eligible encounters (denominator). We used generalized estimating equations accounting for hospital clustering to analyze trends over time for individual measures, with year of encounter as a covariate; the resultant odds ratio and *P* value therefore reflect the significance of annual change over the study period.

After initial analyses revealed apparent trajectory changes for some measures coinciding with the onset of the severe acute respiratory syndrome coronavirus disease 2019 (COVID-19) pandemic in 2020, we performed an analysis comparing annual rates of change in the percentage of encounters with LVC delivery over 2 periods: (1) 2016 to 2019 (preceding the COVID-19 pandemic), and (2) 2020 to 2022 (onset of the pandemic to present). Rates of changes for these periods were compared with *t* tests to assess whether LVC patterns observed during and after the pandemic differed from those observed before the pandemic.

We additionally assessed observed changes by category of measure (medications, laboratory and imaging studies, and procedures). Finally, we ranked measures by the proportion and volume of encounters with LVC delivery at the conclusion of the study period.

After initial data review, 1 measure, group A streptococcus (GAS) testing for children <3 years of age for routine pharyngitis in the ED, was excluded from further analyses. The definition for this measure captures rapid antigen testing for GAS only; however, recent literature suggests a practice shift toward the use of molecular testing.[29,30] As such, apparent reductions in GAS testing may represent missed molecular testing (for which PHIS has not yet validated a coding approach).

Statistical analyses were performed with SAS, version 9.5 (SAS Institute, Cary, North Carolina), and $P < .05$ was considered statistically significant. This study was deemed not human subjects research by the Dartmouth College institutional review board.

RESULTS

There were 6 566 766 encounters eligible for ≥1 LVC Calculator measure among 43 hospitals contributing data for the entire study period (5 265 153 ED encounters; 1 301 613 encounters for hospitalizations). In both cohorts, encounters eligible for each measure were relatively stable from 2016 to 2019, but decreased markedly in 2020, as did all pediatric encounters in PHIS.[31] By 2022, volume of eligible encounters approximated those observed at the start of the study period for most measures (Tables 1 and 2).

Of 21 measures applicable to the ED cohort, the proportion of eligible encounters in which LVC was delivered increased for 11 measures, suggesting declining performance over the study period (Table 1). LVC delivery decreased for 1 measure and was unchanged for 9 measures. Figure 1 shows trends for measures demonstrating a statistically significant change of ≥5% from 2016 to 2022. LVC increased by ≥5% for 3 measures: Head computed tomography (CT) for minor head injury (16.5% of eligible encounters in 2016 to 22.9% in 2022); head CT for first-time, generalized, afebrile seizure (12.7%–18.4%); and C-reactive protein and/or erythrocyte sedimentation rate for uncomplicated CAP (4.7% to 10.6%). LVC decreased by ≥5% for one measure: bronchodilators for bronchiolitis (22.3%–16.8%). By 2022, the proportion of encounters with LVC delivery was greatest for CT for minor head injury (22.9%) and afebrile seizure (18.4%); measures with the greatest volume of encounters with LVC delivery were chest radiography for asthma (10 468) and CT for minor head injury (8735) (Supplemental Table 5).

Table 2 demonstrates temporal trends in LVC delivery for the hospitalized cohort. Of 26 applicable measures, the proportion of eligible encounters in which LVC was delivered increased for 6 measures and decreased for 9 measures, whereas performance for 11 measures remained unchanged. Figure 2 demonstrates trends for measures with statistically significant changes of ≥5% from 2016 to 2022. LVC increased by ≥5% for 3 measures: Electrolyte testing for simple febrile seizure (27%–38.4%), C-reactive protein and/or erythrocyte sedimentation rate for CAP (23.2%–37.9%), and head CT for first-time generalized afebrile seizure (6.9%–13.3%). LVC decreased by ≥5% for five measures: Broad-spectrum antibiotic therapy for CAP (60.3%–48.3%), acid suppression medications administered to children hospitalized on the pediatric ward (54.9%–49.4%) and those in the NICU (15.8%–8.6%), peripherally-inserted central catheter placement for bone

TABLE 1 Low-Value Care Delivery by Measure, Emergency Department Cohort

		2016		2017		2018		2019		2020		2021		2022				
Condition	Measure	Eligible Encounters (*N*)	Percentage Encounters With LVC Delivery	Eligible Encounters (*N*)	Percentage Encounters With LVC Delivery	Eligible Encounters (*N*)	Percentage Encounters With LVC Delivery	Eligible Encounters (*N*)	Percentage Encounters With LVC Delivery	Eligible Encounters (*N*)	Percentage Encounters With LVC Delivery	Eligible Encounters (*N*)	Percentage Encounters With LVC Delivery	Eligible Encounters (*N*)	Percentage Encounters With LVC Delivery	Odds Ratio for Y	95% Confidence Interval	*P*
		Measures with increasing LVC over the study period																
Head injury	Head CT for minor head injury	44 652	16.5	42 678	16.9	38 847	16.9	38 716	17.5	23 765	23.0	32 367	23.5	38 120	22.9	1.09	1.06–1.11	<.001
Seizure	Head CT for first generalized atraumatic seizure	7714	12.7	7544	13.4	7831	13.6	7969	13.9	7226	16.1	9036	17.7	11 004	18.4	1.08	1.06–1.11	<.001
Headache	Head CT for acute atraumatic primary headache	37 114	11.8	37 268	12.0	35 790	12.2	36 034	12.3	21 290	14.8	26 683	15.6	29 254	16.7	1.08	1.06–1.10	<.001
Pneumonia	Blood cultures for uncomplicated CAP	21 859	7.4	19 453	7.3	18 294	6.8	22 330	7.4	7301	8.5	7852	9.9	13 653	9.8	1.06	1.03–1.09	<.001
Febrile seizure	Electrolyte testing for simple febrile seizure	9605	5.1	9008	4.8	9310	5.8	9473	5.8	5406	8.4	8593	8.3	11 641	7.0	1.09	1.02–1.15	.009
Pneumonia	C-reactive protein and/or erythrocyte sedimentation rate for uncomplicated CAP	21 914	4.7	19 517	5.4	18 333	5.3	22 408	6.5	7330	7.4	7897	9.7	13 713	10.6	1.16	1.09–1.24	<.001
Bronchiolitis	Corticosteroids for bronchiolitis	47 595	4.4	47 676	4.3	45 878	4.3	51 381	4.0	18 002	4.2	41 110	5.4	49 724	7.5	1.10	1.05–1.15	<.001
Abdominal pain	CT of the abdomen for abdominal pain	107 836	3.5	110 032	3.3	111 894	3.5	110 495	3.8	72 176	5.0	95 750	5.5	111 598	5.0	1.10	1.06–1.13	<.001
Headache	MRI of the head for acute atraumatic primary headache	37 114	2.9	37 268	2.9	35 790	3.7	36 034	4.4	21 190	5.8	26 683	5.8	29 254	6.0	1.16	1.09–1.24	.001
Febrile seizure	Head CT for simple febrile seizure	10 150	0.9	9591	0.1	9783	1.1	9922	1.0	5683	1.4	9061	1.3	12 205	1.3	1.07	1.02–1.12	.003
Febrile seizure	MRI of the head for simple febrile seizure	9605	0.0	9591	0.1	9783	0.1	9922	0.1	5683	0.2	9061	0.1	12 205	0.1	1.17	1.04–1.32	.012
		Measures with decreasing LVC over the study period																
Bronchiolitis	Bronchodilators for bronchiolitis	47 595	22.3	47 676	18.2	45 878	17.0	51 381	15.1	18 002	14.7	41 110	15.2	49 724	16.8	0.94	0.91–0.97	.001
		Measures with stable LVC delivery over the study period																
Bronchiolitis	Chest radiography for bronchiolitis	47 595	17.4	47 676	16.4	45 878	15.2	51 381	15.4	18 002	16.2	41 110	15.5	49 724	14.3	0.97	0.93–1.01	.19
Pneumonia	Antibiotics broader than ampicillin for CAP	21 885	15.8	19 482	15.7	18 301	14.6	22 353	13.9	7306	14.8	7869	14.0	13 707	14.3	0.98	0.95–1.00	.09
Asthma	Chest radiography for asthma	73 163	15.0	73 636	15.0	68 567	15.3	63 848	15.5	29 620	17.4	48 117	16.5	63 593	16.5	1.02	0.99–1.06	.13
Febrile seizure	Complete blood cell count for simple febrile seizure	9605	8.2	9088	7.3	9310	7.1	9473	7.2	5406	9.7	8593	8.9	11 641	6.7	1.00	0.95–1.04	.93
Gastroesophageal reflux	Acid suppression therapy for infants <1 y of age	12 940	2.2	12 240	2.1	11 418	2.5	10 711	2.2	8172	1.9	9047	1.7	7869	2.2	0.97	0.93–1.02	.23
Bronchiolitis	Blood cultures for bronchiolitis	44 831	1.5	44 852	1.5	43 241	1.4	48 417	1.3	16 912	1.2	38 623	1.5	46 301	1.4	0.99	0.95–1.04	.83
Bronchiolitis	Antibiotics for bronchiolitis without possible bacterial infection	39 980	0.4	40 037	0.3	38 643	0.3	42 958	0.2	15 260	0.2	34 961	0.2	41 774	0.4	0.98	0.93–1.03	.47
Upper respiratory infection	Antibiotics for viral upper respiratory infection without possible bacterial infection	320 083	0.3	334 769	0.2	327 476	0.2	335 661	0.3	153 402	0.3	323 872	0.2	360 380	0.3	1.02	0.99–1.05	.16
Asthma	Antibiotics for asthma without possible bacterial infection	70 386	0.2	70 904	0.1	66 544	0.2	61 865	0.2	28 954	0.2	47 135	0.2	61 865	0.2	1.01	0.96–1.06	.76

TABLE 2 Low-Value Care Delivery by Measure, Hospitalized Cohort

		2016		2017		2018		2019		2020		2021		2022				
Condition	Measure	Eligible Encounters (*N*)	Percentage Encounters With LVC Delivery	Eligible Encounters (*N*)	Percentage Encounters With LVC Delivery	Eligible Encounters (*N*)	Percentage Encounters With LVC Delivery	Eligible Encounters (*N*)	Percentage Encounters With LVC Delivery	Eligible Encounters (*N*)	Percentage Encounters With LVC Delivery	Eligible Encounters (*N*)	Percentage Encounters With LVC Delivery	Eligible Encounters (*N*)	Percentage Encounters With LVC Delivery	Odds Ratio for Y	95% Confidence Interval	*P*
		Measures with increasing LVC over the study period																
Asthma	Chest radiography for asthma	19 676	30.8	19 011	30.9	19 276	32.0	17 517	32.2	7948	35.0	14 636	33.7	20 372	34.2	1.03	1.01–1.05	.009
Febrile seizure	Electrolyte testing for simple febrile seizure	486	27.0	476	30.0	479	32.6	499	29.9	323	37.2	415	40.7	497	38.4	1.1	1.01–1.20	.027
Pneumonia	C-reactive protein and/or erythrocyte sedimentation rate for uncomplicated CAP	4895	23.2	4362	26.5	4385	26.7	5300	30.1	1913	31.3	2063	37.5	3864	37.9	1.12	1.04–1.22	.003
Bronchiolitis	Corticosteroids for bronchiolitis	18 304	10.1	18 679	10.3	19 088	10.2	20 398	10.1	8101	9.5	17 447	10.8	22 226	12.8	1.04	1.01–1.06	.003
Seizure	Head CT for first generalized atraumatic seizure	4493	6.9	4276	7.4	3570	9.3	3563	9.4	2890	13.0	3769	13.1	3949	13.3	1.14	1.08–1.21	< .001
Febrile seizure	Head CT for simple febrile seizure	553	5.2	556	5.2	537	9.3	569	6.9	375	9.9	492	7.9	578	9.9	1.1	1.05–1.17	< .001
		Measures with decreasing LVC over the study period																
Pneumonia	Antibiotics broader than ampicillin for CAP	4818	60.3	4275	57.6	4292	55.7	5151	60.0	1851	57.3	1979	49.3	3839	48.3	0.93	0.90–0.96	< .001
Gastroesophageal reflux	Acid suppression therapy for infants <1 y of age	7858	54.9	7587	54.5	7134	53.6	6855	51.0	5027	43.2	5834	45.9	5382	49.4	0.94	0.92–0.96	< .001
Bronchiolitis	Bronchodilators for bronchiolitis	18 304	37.4	18 679	34.0	19 088	33.5	20 398	29.9	8101	27.6	17 447	29.6	22 226	30.9	0.95	0.91–0.99	.01
Bronchiolitis	Chest radiography for bronchiolitis	18 304	30.8	18 679	29.7	19 088	29.1	20 398	27.9	8101	27.0	17 447	26.9	22 226	27.2	0.97	0.94–1.0	.03
Neonatal intensive care	Acid suppression therapy for treatment of gastroesophageal reflux or apnea and desaturation	297	15.8	317	12.6	240	11.7	231	14.7	205	5.9	194	6.2	162	8.6	0.86	0.79–0.94	.001
Bone and joint infections	Extended intravenous antibiotic therapy for bone and joint infection	1843	15.7	1948	14.6	1993	13.5	2000	12.1	1724	8.7	1577	7.7	1766	6.1	0.83	0.78–0.89	< .001
Appendicitis	Extended intravenous antibiotic therapy for ruptured appendicitis	8079	5.9	8628	4.8	8529	4.4	6834	5.5	7077	4.2	6608	3.3	6600	2.7	0.90	0.84–0.97	.003
Bronchiolitis	Antibiotics for bronchiolitis without possible bacterial infection	12 436	5.1	12 757	4.0	13 378	3.8	14 031	4.1	5791	3.6	12 841	3.2	16 007	4.0	0.96	0.92–1.0	.04
Behavioral health	Antipsychotic medications for children aged <5 y	94 495	0.1	93 399	0.1	94 575	0.1	98 589	0.1	62 563	0.1	88 524	0.1	107 861	0.1	0.94	0.89–0.99	.01
		Measures with stable LVC delivery over the study period																
Pneumonia	Blood cultures for uncomplicated CAP	4874	37.5	4358	38.2	4388	38.8	5306	39.1	1926	39.5	2075	43.9	3870	39.4	1.02	0.97–1.07	.36
Febrile seizure	Complete blood cell count for simple febrile seizure	486	35.8	476	37.2	479	37.8	499	33.5	323	39.0	415	43.4	497	39.0	1.03	0.98–1.09	.19
Behavioral health	2 or more concurrent antipsychotic medications	13 694	21.0	13 921	21.0	14 337	21.1	14 487	20.9	13 120	22.1	15 516	22.2	15 775	22.8	1.02	1.0–1.04	.05
Abdominal pain	CT of the abdomen for abdominal pain	6879	13.6	6646	13.1	6348	13.3	6148	12.7	4397	16.4	5493	15.3	5461	13.8	1.02	1.0–1.05	.09
Bronchiolitis	Blood cultures for bronchiolitis	15 492	10.3	15 842	9.4	16 510	5.3	17 598	9.1	7057	8.3	15 159	9.6	19 461	8.5	0.98	0.91–1.05	.48
Febrile seizure	MRI of the head for simple febrile seizure	553	9.2	556	4.9	537	6.9	569	5.4	375	7.7	492	4.7	578	4.7	0.92	0.84–1.0	.05

TABLE 2 Continued

Condition	Measure	2016		2017		2018		2019		2020		2021		2022				
		Eligible Encounters (*N*)	Percentage Encounters With LVC Delivery	Eligible Encounters (*N*)	Percentage Encounters With LVC Delivery	Eligible Encounters (*N*)	Percentage Encounters With LVC Delivery	Eligible Encounters (*N*)	Percentage Encounters With LVC Delivery	Eligible Encounters (*N*)	Percentage Encounters With LVC Delivery	Eligible Encounters (*N*)	Percentage Encounters With LVC Delivery	Eligible Encounters (*N*)	Percentage Encounters With LVC Delivery	Odds Ratio for Y	95% Confidence Interval	*P*
Upper respiratory infection	Antibiotics for viral upper respiratory infection without possible bacterial infection	21 868	6.6	23 174	5.6	23 795	5.7	25 115	5.6	10 031	6.5	22 595	4.4	28 959	6.0	0.98	0.95–1.01	.13
Pneumonia	Extended intravenous antibiotic therapy for complicated pneumonia	725	5.2	672	3.1	640	3.3	763	3.3	316	2.5	234	2.1	485	2.3	0.87	0.73–1.03	.11
Neonatal intensive care	Vancomycin or carbapenems without risk for resistant pathogens	25 743	2.5	25 746	2.4	22 628	2.6	22 629	2.5	20 144	2.4	19 934	2.2	20 436	2.5	0.99	0.94–1.05	.74
Asthma	Antibiotics for asthma without possible bacterial infection	18 818	2.0	18 175	2.0	18 547	2.0	16 856	2.1	7717	2.0	14 256	1.8	19 662	1.8	0.98	0.94–1.02	.26
Asthma	Ipratropium bromide after 24 h of hospitalization	19 676	1.7	19 011	2.0	19 276	1.9	17 517	2.2	7948	2.0	14 636	1.9	20 372	2.1	1.02	0.93–1.12	.69

and joint infections (15.7%–6.1%), and bronchodilators for bronchiolitis (37.4%–30.9%). By 2022, the proportion of encounters with LVC delivery was greatest for acid suppression therapy for infants with gastroesophageal reflux (49.4%) hospitalized on the pediatric ward and broad-spectrum antibiotic therapy (48.3%); measures with the greatest volume of encounters with LVC delivery were chest radiography for asthma (6963) and bronchodilators for bronchiolitis (6868) (Supplemental Table 5).

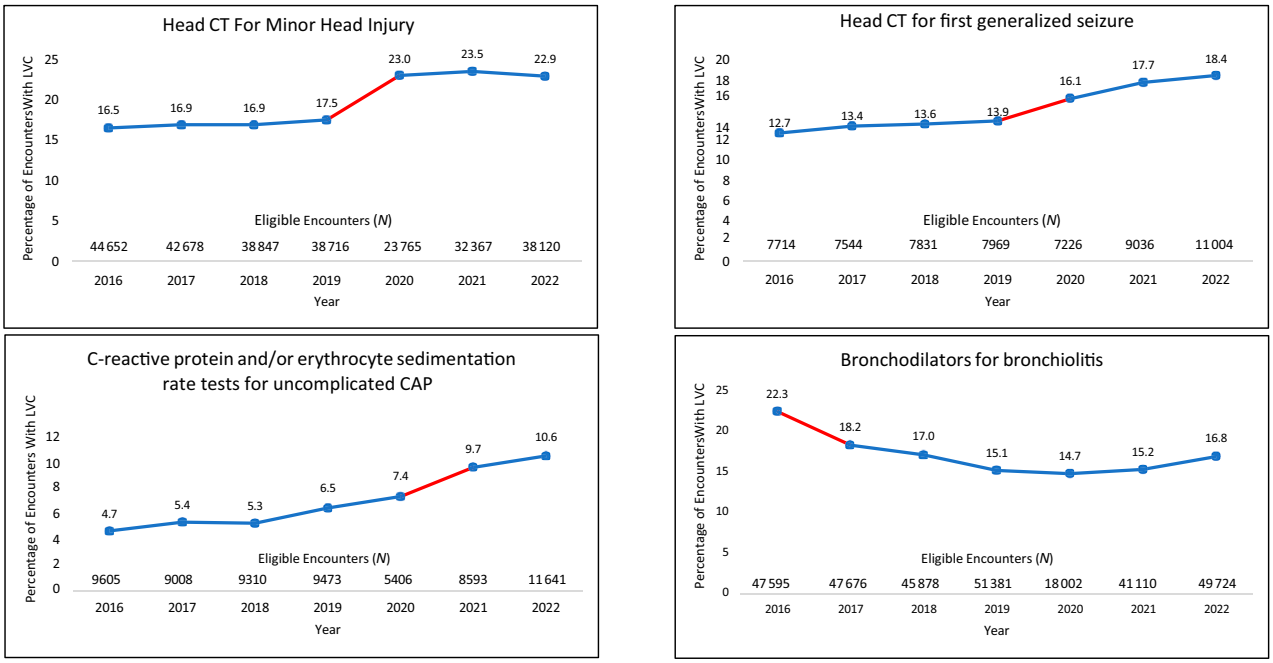
Table 3 compares annual rates of change by measure from 2016 to 2019 and from 2020 to 2022. No statistically significant difference in annual rates of change was noted between these 2 time periods for any measure.

Supplemental Table 6 shows performance by measure category. LVC was either unchanged or decreased for nearly all medication measures in both cohorts; the exception was steroids for bronchiolitis, which increased in both cohorts over the study period (Tables 1 and 2). For the 3 procedure measures (only applicable to the inpatient cohort), LVC was also unchanged or decreased. For all 5 laboratory measures, LVC was either unchanged or increased in both cohorts. For the 9 imaging measures, LVC was also unchanged or increased for nearly all measures in both cohorts, with the exception of chest radiography for bronchiolitis in the inpatient cohort, which decreased (Table 2).

DISCUSSION

Our study identified varying performance trajectories across a set of hospital-based LVC measures from 2016 to 2022, with differences identified by measure category. LVC was unchanged or decreased for most medication and procedural measures; conversely, LVC was either unchanged or increased for all laboratory measures and nearly all imaging measures. Among all 29 measures, the majority demonstrated relative performance stagnation over the study period, with many demonstrating persistently high rates of LVC delivery in 2022.

This study adds to existing literature by exploring a broad set of hospital-based pediatric LVC measures and providing recent longitudinal data for several previously studied measures. We found ongoing improvement in LVC delivery for some services, such as bronchodilators for bronchiolitis. This continued improvement may reflect the robust evidence base,[32] dissemination of national recommendations,[33] and numerous quality improvement initiatives dedicated to reducing LVC for this common diagnosis.[34] However, we also identified reversal of previous improvement trends for some measures, including chest radiography for asthma,[2] head CT for minor head injury,[35] and corticosteroids for bronchiolitis.[17] These findings may suggest challenges in sustainability of deimplementation efforts; additionally, they support a need for consistent LVC measurement to facilitate timely identification of such shifts. Our observation that LVC failed to improve for a majority of included measures



Measures with the greatest change are defined as those with a statistically significant change of ≥5% over the study period. Red line segments indicate the greatest annual change over the study period.

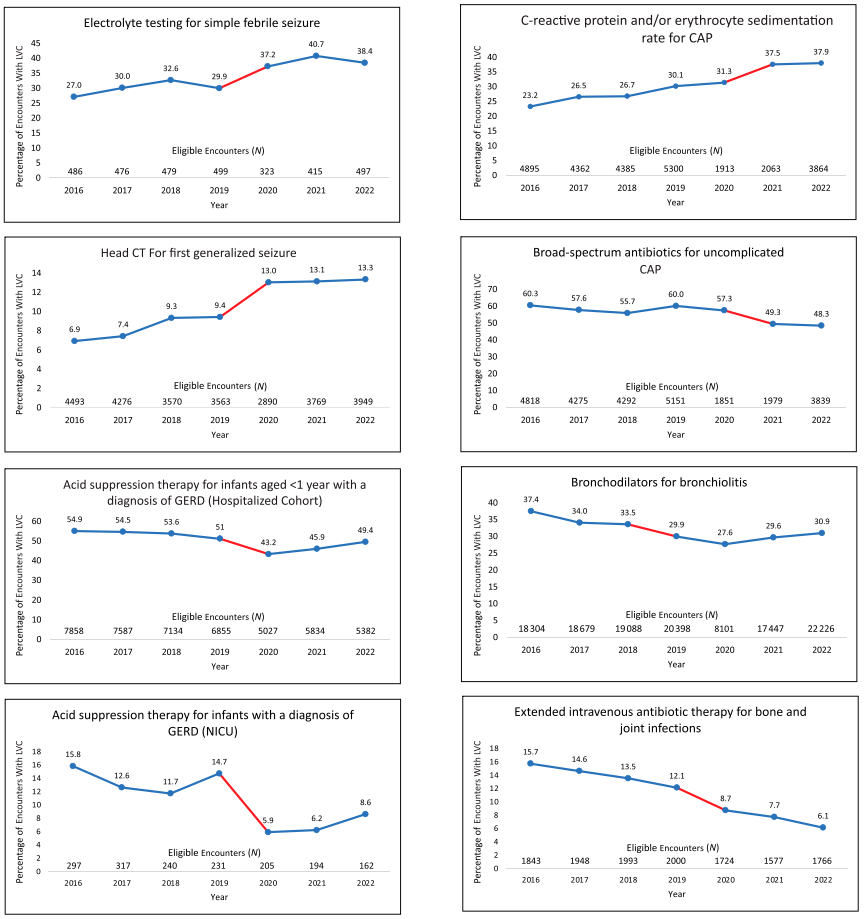
FIGURE 1

LVC measures demonstrating the greatest change over the study period: ED cohort. Measures with the greatest change are defined as those with a statistically significant change of >5% over the study period. Red line segments indicate the greatest annual change over the study period.

mirrors results from several studies focused on adult populations, which have found minimal improvements in LVC over time despite an intensified awareness of the harms associated with these services.[36–38]

The differential patterns observed between measures associated with the diagnostic process (laboratory and imaging studies, for which LVC was generally unchanged or increasing) and those associated with treatment (medications and procedures, for which LVC was unchanged or decreasing) is notable. Although reductions in low-value medications and procedures are key successes, efforts are needed to deimplement services further upstream in the diagnostic process. Such attention may reduce misdiagnosis and overdiagnosis[39] and prevent cascades of LVC, defined as medical services that directly follow from an initial low-value service.[40] For example, avoidance of chest radiography for bronchiolitis not only reduces direct costs and harm from radiation, but may also prevent a misdiagnosis of bacterial pneumonia on the basis of nonspecific imaging findings (eg, a focal opacity which may be consistent with atelectasis) and therefore avoid a course of antibiotics and associated harms. Our findings highlight the importance of continued efforts to measure the downstream impact of diagnostic services and focus on diagnostic stewardship.[41]

Our results raise some questions surrounding the potential influence of the COVID-19 pandemic on pediatric LVC. Literature supports a marked reduction in pediatric health care services at the start of the pandemic accompanied by shifts in common disease patterns,[42] yet little is known about pandemic-related changes in health care value. For some LVC Calculator services, such as head CT for minor head injury (ED cohort) and for generalized seizure (both cohorts), inflammatory marker testing for uncomplicated CAP (both cohorts), and electrolyte testing for febrile seizures (hospitalized cohort), a large increase in LVC was observed after the onset of the COVID-19 pandemic. It is possible that changes introduced by the pandemic may have directly altered LVC patterns. For example, providers may have felt more compelled to obtain definitive diagnostic information to avoid longer observation periods in the health care setting and reduce likelihood of follow-up care needs. Alternatively, alterations in patient acuity may have influenced these trends. For example, children seeking care for minor head injury during the pandemic may have had more severe symptomatology than those presenting during other periods of our study, because caregivers may have attempted to minimize health care contact during the pandemic due to infectious risks. The trajectories of these measures in the postpandemic period have varied, with some increases continuing and others tempering. Annual rates of change do not yet demonstrate significant differences for any services between the prepandemic period (2016–2019) and the study period inclusive of the pandemic and postpandemic years (2020–2022). Further



Measures with the greatest change are defined as those with a statistically significant change of ≥5% over the study period. Red line segments indicate the greatest annual change over the study period.

FIGURE 2

LVC measures demonstrating the greatest change over the study period: Hospitalized cohort. Measures with the greatest change are defined as those with a statistically significant change of >5% over the study period. Red line segments indicate the greatest annual change over the study period.

measurement, particularly of services that are continuing to increase, and assessment of drivers will be needed to elucidate the impact of the pandemic on LVC.

Given lack of improvement in LVC delivery for many measures over this study period, a structured approach is needed to identify and prioritize services for which deimplementation efforts will be most impactful. The LVC Calculator may assist with achieving this aim by offering continuous data describing multiple aspects of LVC measurement including prevalence, cost, and temporal trends. We identified temporal increases in some measures, such as CT for minor head injury (ED cohort) and for first-time generalized seizure (both cohorts) for which LVC has been shown to be particularly costly[3] and harmful,[43–45] suggesting these services are important areas for prioritized deimplementation. Targeted deimplementation may also benefit measures demonstrating stagnant performance where LVC remains prevalent. For example, in the ED cohort, chest radiography remained unchanged through the study period, but was delivered in >10 000 encounters in 2022 (nearly 17% of those eligible); in the hospitalized cohort, blood cultures for CAP also remained unchanged, but were obtained in >1500 encounters (nearly 40% of those eligible). Our previous work also found these services to be relatively costly and to impact a large number of children.[3] For such measures, comparing current performance to achievable benchmarks of care[22,46] will identify realistic improvement potential and offer improvement targets. Further work is needed to systematically assess other key areas of LVC impact, including perceived degree of harm associated with each service, potential for cascades of care, and disparities that may impact health equity; additionally, future efforts should focus on further characterizing drivers and outcomes associated with this care.

Our study has important limitations. First, our definition of LVC relies on administrative data. Although the measure definitions in the LVC Calculator are intentionally narrow, intending to identify services that are truly low-value, it is possible that some services were misclassified as low-value. Conversely, it is possible that the measure definitions may underestimate the burden of LVC. Although

TABLE 3 Percentage Change in Low-Value Care Delivery Before and After the Onset of the SARS-CoV-2 Pandemic

Condition	Measure	Cohort	Average Annual Change in Percentage LVC Delivery: 2016–2019	Average Annual Change in Percentage LVC Delivery: 2020–2022	Mean Difference	95% Confidence Intervals	*P*
Abdominal pain	Children with abdominal pain should not routinely have CT imaging of the abdomen performed unless other indications are present.	ED	0.1 (−0.5 to 0.7)	0.4 (−1.8 to 2.6)	−0.3	−2.3 to 1.7	.64
		Hospitalized	−0.3 (−1.5 to 0.9)	0.4 (−7.0 to −7.7)	−0.7	−7.8 to 6.4	.73
Appendicitis	Children diagnosed with ruptured appendicitis should not have peripherally inserted central lines or central venous lines placed for extended intravenous antibiotic therapy.	Hospitalized	−0.1 (−2.9 to 2.6)	−0.9 (−1.7 to −0.1)	0.8	−1.7 to 3.3	.35
Asthma	Children diagnosed with asthma should not routinely have a chest x-ray performed.	ED	0.2 (−0.1 to 0.5)	0.3 (−3.4 to 4)	−0.1	−3.8 to 3.5	.88
		Hospitalized	0.5 (−0.8 to 1.7)	0.7 (−4.5 to 5.9)	−0.2	−5.1 to 4.6	.88
	Children diagnosed with asthma should not be treated with antibiotic medications unless they are also diagnosed with a possible bacterial infection.	ED	0.0 (0.0–0.0)	0.0 (0.0–0.0)	0.00	0.0–0.0	.69
		Hospitalized	0.0 (−0.1 to 0.2)	−0.1 (−0.4 to 0.2)	0.1	−0.1 to 0.4	.18
	Children admitted to the hospital with acute exacerbation of asthma should not receive ipratropium bromide after 24 h of hospitalization.	Hospitalized	0.2 (−0.4 to 0.7)	0.0 (−0.5 to 0.4)	0.2	−0.3 to 0.7	.29
Behavioral health	Children aged <5 y should not routinely receive antipsychotic medications.	Hospitalized	0.0 (0.0–0.0)	0.0 (0.0–0.0)	0.0	0.0–0.0	.33
	Children receiving antipsychotic medications should not routinely receive 2 or more antipsychotic medications concurrently.	Hospitalized	0.0 (−5.0 to 0.4)	0.6 (−0.8 to 2.1)	−0.6	−1.9 to 0.7	.19
Bone and joint infections	Children diagnosed with bone and joint infections should not have peripherally inserted central lines or central venous lines placed for extended intravenous antibiotic therapy.	Hospitalized	−1.2 (−1.8 to −0.6)	−2.0 (−5.1 to 1.1)	0.8	−2.1 to 3.7	.39
Bronchiolitis	Children diagnosed with bronchiolitis should not be treated with corticosteroids.	ED	−0.1 (−0.5 to 0.3)	1.2 (−1.3 to 3.6)	−1.3	−3.6 to 1.1	.15
		Hospitalized	0.0 (−0.5 to 0.5)	0.9 (−2.4 to 4.2)	−0.9	−4.2 to 2.3	.35
	Children diagnosed with bronchiolitis should not routinely receive treatment with bronchodilators.	ED	−2.4 (−6.1 to 1.2)	0.6 (−1.8 to 3)	−3.0	−6.0 to 0.0	.05
		Hospitalized	−2.5 (−6.8 to 1.8)	0.3 (−5.5 to 6.2)	−2.8	−7.7 to 2.0	.18
	Children diagnosed with bronchiolitis should not have a chest x-ray performed.	ED	−0.7 (−2.5 to 1.1)	−0.4 (−3.1 to 2.3)	−0.3	−2.5 to 1.9	.71
		Hospitalized	−1.0 (−1.9 to −0.1)	−0.2 (−1.7 to 1.2)	−0.7	−1.9 to 0.4	.15
	Children diagnosed with bronchiolitis should not have bacterial blood cultures performed.	ED	−0.1 (−0.3 to 0.2)	0.0 (−0.6 to 0.7)	−0.1	−0.7 to 0.4	.50
		Hospitalized	−0.4 (−1.4 to 0.6)	−0.2 (−3.3 to 2.9)	−0.2	−2.9 to 2.6	.84
	Children diagnosed with bronchiolitis should not be treated with antibiotic medications unless they are also diagnosed with a possible bacterial infection.	ED	0.0 (−0.1 to 0.1)	0.0 (−0.1 to 0.2)	−0.1	−0.2 to 0.1	.18
		Hospitalized	−0.3 (−2 to 1.3)	0.0 (−1.8 to 1.8)	−0.3	−1.9 to 1.3	.61

TABLE 3 Continued

Condition	Measure	Cohort	Average Annual Change in Percentage LVC Delivery: 2016–2019	Average Annual Change in Percentage LVC Delivery: 2020–2022	Mean Difference	95% Confidence Intervals	*P*
Febrile seizure	Children diagnosed with a simple febrile seizure should not routinely have electrolyte testing performed for the sole purpose of identifying the cause of the seizure.	ED	0.2 (−1.4 to 1.9)	0.4 (−4.6 to 5.3)	−0.1	−4.6 to 4.3	.92
		Hospitalized	1.0 (−7 to 8.9)	2.9 (−9.1 to 14.9)	−1.9	−11.8 to 8	.61
	Children diagnosed with a simple febrile seizure should not routinely receive MRI of the head.	ED	0.0 (−0.1 to 0.1)	0.0 (−0.2 to 0.3)	0.0	−0.2 to 0.2	.88
		Hospitalized	−1.3 (−9.2 to 6.7)	−0.3 (−6.9 to 6.4)	−1.0	−7.8 to 5.8	.70
	Children diagnosed with a simple febrile seizure should not routinely receive CT imaging of the head.	ED	0.0 (−0.1 to 0.2)	0.1 (−0.5 to 0.6)	0.0	−0.5 to 0.5	.79
		Hospitalized	0.5 (−7.7 to 8.8)	1.0 (−5.5 to 7.5)	−0.5	−7.4 to 6.4	.86
	Children diagnosed with a simple febrile seizure should not routinely have complete blood count testing performed for the sole purpose of identifying the cause of the seizure.	ED	−0.4 (−1.7 to 1.0)	−0.1 (−6.2 to 5.9)	−0.2	−5.9 to 5.5	.89
		Hospitalized	−0.8 (−8.5 to 6.9)	1.9 (−11.6 to 15.3)	−2.6	−13.7 to 8.4	.51
Gastroesophageal reflux	Infants aged <1 y should not be routinely treated with acid suppression therapy.	ED	0.0 (−0.9 to 0.9)	0.0 (−1.1 to 1.1)	0	−0.9 to 0.9	.98
		Hospitalized	−1.3 (−4.2 to 1.6)	−0.5 (−16.2 to 15.2)	−0.7	−15.8 to 14.3	.86
Headache	Children seen and treated in the ED for acute atraumatic primary headache should not routinely receive CT imaging of the head.	ED	0.2 (0.0–0.3)	1.5 (−0.8 to 3.7)	−1.3	−3.6 to 0.9	.13
	Children seen and treated in the ED for acute atraumatic primary headache should not routinely receive MRI of the head.	ED	0.5 (−0.6 to 1.7)	0.5 (−1.2 to 2.3)	0.0	−1.4 to 1.4	.97
Head injury	Children seen and treated in the ED for minor head injuries should not routinely receive a brain CT scan.	ED	0.3 (−0.3 to 1.0)	1.8 (−6.3 to 9.9)	−1.5	−9.5 to 6.6	.52
Neonatal intensive care	Infants in the NICU should not receive antireflux medications for treatment of symptomatic gastroesophageal reflux or for the treatment of apnea and desaturation.	Hospitalized	−0.4 (−8.2 to 7.5)	−2.0 (−17 to 12.9)	1.7	−10.8 to 14.1	.70
	Infants in the NICU should not receive vancomycin or carbapenems unless there is a known risk for resistant pathogens.	Hospitalized	0.0 (−0.5 to 0.5)	0.0 (−0.7 to 0.7)	0.0	−0.6 to 0.6	.95
Pneumonia	Children diagnosed with uncomplicated CAP should not have C-reactive protein and/or erythrocyte sedimentation rate tests performed.	ED	0.6 (−1 to 2.1)	1.4 (−0.6 to 3.3)	−0.8	−2.5 to 0.9	.25
		Hospitalized	2.3 (−2.3 to 6.8)	2.6 (−5.2 to 10.4)	−0.3	−6.7 to 6.2	.90
	Children diagnosed with uncomplicated CAP should not routinely have bacterial blood cultures performed.	ED	0.0 (−1.3 to 1.2)	0.8 (−1.3 to 2.9)	−0.8	−2.5 to 0.9	.24
		Hospitalized	0.5 (0.1–1)	0.1 (−11 to 11.2)	0.4	−10.6 to 11.5	.88

TABLE 3 Continued

Condition	Measure	Cohort	Average Annual Change in Percentage LVC Delivery: 2016–2019	Average Annual Change in Percentage LVC Delivery: 2020–2022	Mean Difference	95% Confidence Intervals	*P*
	Children diagnosed with uncomplicated CAP should not be treated with antibiotic therapies broader than ampicillin.	ED	−0.6 (−1.9 to 0.7)	0.1 (−2 to 2.3)	−0.8	−2.5 to 1	.27
		Hospitalized	−0.1 (−9.7 to 9.5)	−3.9 (−13.1 to 5.2)	3.8	−4.7 to 12.4	.28
	Children diagnosed with complicated pneumonia should not have peripherally inserted central lines or central venous lines placed for extended intravenous antibiotic therapy.	Hospitalized	−0.7 (−3.8 to 2.5)	−0.3 (−1.4 to 0.8)	−0.3	−3.1 to 2.5	.71
Seizure	Children diagnosed with their first generalized afebrile atraumatic seizure should not have CT imaging of the head performed.	ED	0.4 (−0.2 to 1)	1.5 (−0.4 to 3.5)	−1.1	−2.9 to 0.6	.12
		Hospitalized	0.8 (−1.4 to 3.1)	1.3 (−3.6 to 6.2)	−0.5	−4.6 to 3.7	.74
Upper respiratory infection	Children diagnosed with viral upper respiratory infections should not be treated with antibiotic medications unless they are also diagnosed with a possible bacterial infection.	ED	0.0 (−0.1 to 0.1)	0.0 (−0.1 to 0.2)	0.0	−0.2 to 0.1	.56
		Hospitalized	−0.3 (−1.8 to 1.1)	0.1 (−4.7 to 4.9)	−0.4	−4.8 to 3.9	.74

SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.

the LVC Calculator's design is intended to exclude children with severe illness, it is possible that variations in patient characteristics, including acuity, throughout the study period not captured by our exclusion criteria may have influenced LVC receipt. We did not perform statistical analyses describing the significance of short-term changes in LVC delivery during the pandemic; future analyses focused specifically on this period may further elucidate the direct impact of the pandemic on LVC. We did not cluster our analysis at the patient level and are therefore unable to assess the influence of repeated low-value service delivery to an individual patient on our results. Finally, our analysis includes only data from children's hospitals participating in PHIS, and our findings may not be generalizable to other settings.

CONCLUSIONS

This longitudinal assessment of 29 pediatric hospital-based LVC measures demonstrated varying performance trends by measure from 2016 to 2022, with a persistently high prevalence of LVC observed for many measures at the conclusion of the study period. Performance trends were less favorable for diagnostic measures (imaging and laboratory studies) than therapeutic measures (medications and procedures). Given the imperative to reduce LVC delivery and realistic limitations in deimplementation resources, these data may inform prioritization of deimplementation efforts.

ABBREVIATIONS

CAP: community-acquired pneumonia
COVID-19: coronavirus disease 2019
CT: computed tomography
ED: emergency department
GAS: group A streptococcus
LVC: low-value care,
PHIS: Pediatric Health Information System

FUNDING: No external funding.

CONFLICT OF INTEREST DISCLOSURES: The authors have indicated they have no conflicts of interest relevant to this article to disclose.

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