Prolonged Emergency Department Length of Stay for US Pediatric Mental Health Visits (2005–2015)

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abstract

BACKGROUND AND OBJECTIVES: Children seeking care in the emergency department (ED) for mental health conditions are at risk for prolonged length of stay (LOS). A more contemporary description of trends and visit characteristics associated with prolonged ED LOS at the national level is lacking in the literature. Our objectives were to (1) compare LOS trends for pediatric mental health versus non–mental health ED visits and (2) explore patient-level characteristics associated with prolonged LOS for mental health ED visits.

METHODS: We conducted an observational analysis of ED visits among children 6 to 17 years of age using the National Hospital Ambulatory Medical Care Survey (2005–2015). We assessed trends in rates of prolonged LOS and the association between prolonged LOS and demographic and clinical characteristics (race and ethnicity, payer type, and presence of a concurrent physical health diagnosis) using descriptive statistics and survey-weighted logistic regression.

RESULTS: From 2005 to 2015, rates of prolonged LOS for pediatric mental health ED visits increased over time from 16.3% to 24.6% (LOS >6 hours) and 5.3% to 12.7% (LOS >12 hours), in contrast to non–mental health visits for which LOS remained stable. For mental health visits, Hispanic ethnicity was associated with an almost threefold odds of LOS >12 hours (odds ratio 2.74; 95% confidence interval 1.69–4.44); there was no difference in LOS by payer type.

CONCLUSIONS: The substantial rise in prolonged LOS for mental health ED visits and disparity for Hispanic children suggest worsening and inequitable access to definitive pediatric mental health care. Policy makers and health systems should work to provide equitable and timely access to pediatric mental health care.

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Dr Nash conceptualized and designed the study, drafted the initial manuscript, and revised the manuscript; Drs Zima contributed to the conceptualization and design of the study, critically reviewed the manuscript for important intellectual content, and reviewed and revised the manuscript; Mr Rothenberg conducted data analyses and reviewed and revised the manuscript; Drs Moreno, Hoffmann, and Rosenthal contributed to the conceptualization and design of the study and critically reviewed and revised the manuscript; Dr Venkatesh conceptualized and designed the study, critically reviewed the manuscript for important intellectual content, 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.

WHAT'S KNOWN ON THIS SUBJECT: Over time, more children are visiting the emergency department (ED) for mental health conditions and are vulnerable to prolonged length of stay (LOS). National trends in ED LOS and characteristics associated with prolonged LOS have not been well described.

WHAT THIS STUDY ADDS: LOS for pediatric mental health ED visits is increasing over time. By 2014 to 2015, on average, 12.7% of visits exceeded 12 hours. Hispanic children are nearly 3 times as likely to have a prolonged visit than non-Hispanic white children.

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For the increasing number of children who use the emergency department (ED) for mental health needs,[1–12] prolonged ED length of stay (LOS) is a common adverse outcome[13–17] that impacts quality, the patient experience, and efficiency of our health care system.[18–20] Time spent in the ED represents a delay in accessing definitive mental health care.[9,21–23] The ED environment is not well suited to address mental health needs and can be traumatic because of loud noise, frequent changes in providers, and security presence.[24] Furthermore, prolonged LOS leads to general ED crowding, rendering other patients at risk for delays, decreased quality of care,[9,25–28] and leaving the ED without being seen by a provider.[26,29] Acknowledging the impact of prolonged LOS on quality, The Joint Commission defined ED visits >4 hours as prolonged,[30] and the National Quality Forum endorsed 2 relevant measures: NQF0495 and NQF0496.[31]

Previous literature reveals that children who present to the ED with mental health needs are susceptible to prolonged LOS.[13–17,22,32–34] Recent changes to the health care landscape, including the 2010 Affordable Care Act,[35] coupled with efforts at the state, local, and institutional level, may have impacted access to care over time.[11,36–44] Children who are traditionally marginalized as racial and ethnic minorities,[9,16,33] living in poverty and/or publicly insured,[6,8,15] or who are without a concurrent physical health diagnosis may be particularly vulnerable to prolonged LOS.[12,45] More current, nationally representative, pediatric-specific data that describe trends over time and visit characteristics associated with prolonged ED LOS for mental health visits are lacking.

Accordingly, we described more than a decade (2005–2015) of national, temporal trends in ED LOS, comparing pediatric mental health visits with non–mental health visits. Second, we examined whether demographic and clinical characteristics (race and ethnicity, payer type, absence of a concurrent physical health diagnosis) were associated with prolonged ED LOS for mental health visits.

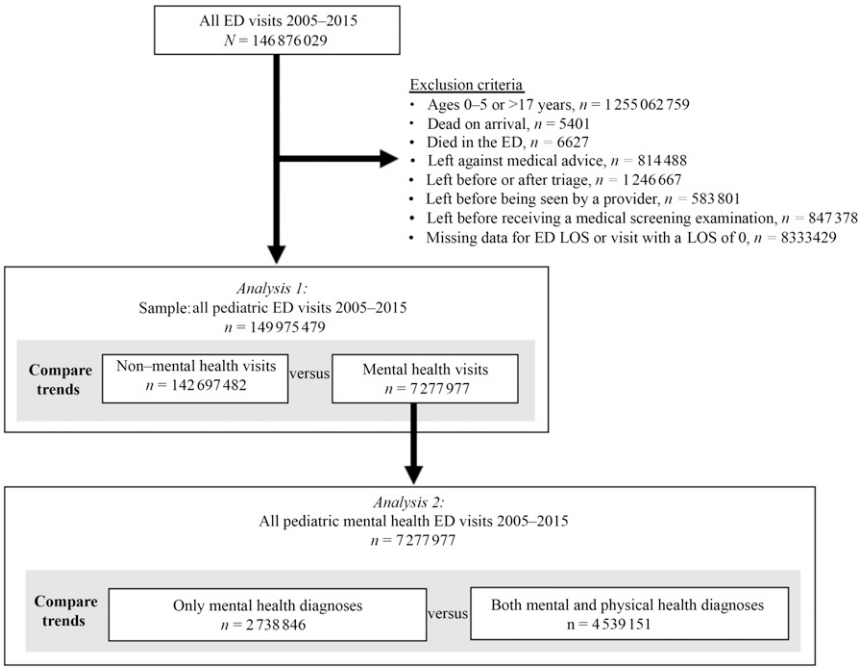

FIGURE 1
Inclusion and exclusion criteria and visit sample used for each analysis.

METHODS

Study Design and Data Source

We conducted an observational analysis of pediatric ED visits between 2005 and 2015 using the National Hospital Ambulatory Medical Care Survey (NHAMCS). NHAMCS is a cross-sectional survey of ambulatory and ED visits to US hospitals (excluding federal, military, and Veterans Affairs facilities) administered by the National Center for Health Statistics (NCHS) of the Centers for Disease Control and Prevention. The NHAMCS uses 3-stage probability sampling to provide survey-weighted national estimates.[46] All NHAMCS data are deidentified and publicly available; this study was exempt from the local institutional review board.

Study Sample

We included ED visits for patients ages 6 to 17 years[6,9,47] between 2005 and 2015. We excluded visits with missing ED LOS data and a LOS of 0 minutes (5% of the total ED visits for ages 6–17), visits of patients who were dead on arrival or died in the ED, and visits of patients who left before or after triage, before being seen by a provider, or against medical advice (Fig 1).

Variables

We examined 3 definitions of our primary outcome, prolonged ED LOS: >6, >12, and >24 hours. ED LOS >6 hours is a conservative approximation of The Joint Commission definition (>4 hours)[30] and consistent with most studies used to examine mental health ED visits.[15,16,32–34,48] We explored 2 additional definitions of prolonged ED LOS, >12 and >24 hours, with face validity as being disruptive to patients' care and experience. We

defined prolonged ED LOS by time cutoffs as opposed to mutually exclusive time intervals to optimize our sample size and ensure model stability.

Consistent with previous studies in which researchers use NHAMCS data,[8,9,15,17,49–51] we defined an ED visit as a mental health visit if any of the first 3 discharge diagnoses contained a mental health *International Classification of Diseases, Ninth Revision* diagnosis code, defined by the Child and Adolescent Mental Health Disorder Classification System. The Child and Adolescent Mental Health Disorder Classification System classifies pediatric mental health disorders across *International Classification of Diseases* coding systems and aligns with the *Diagnostic and Statistical Manual of Mental Health Disorders, Fifth Edition* and Clinical Classifications Software.[52] The full list of diagnostic codes is publicly available on the Children's Hospital Association Web site.[53] We included diagnoses of autism spectrum disorder and developmental delay and injury codes related to suicide attempt and intentional self-harm. We further categorized pediatric mental health ED visits as visits with only mental health diagnoses or visits with both mental and physical health diagnoses.

On the basis of clinical relevance and previous literature, we explored the relationship between prolonged ED LOS and demographic variables: race and ethnicity (NCHS-generated 4-level variable); payer type (private, public, other); and clinical variables: mental health visits with only mental health diagnoses versus mental health visits with both mental and physical health diagnoses.

We reported visits as survey-weighted estimates and rates of prolonged ED LOS as proportions (ED visits with LOS >x hours)/total visits). As recommended by the NCHS, to ensure reliable estimates, we grouped data into 2-year increments and did not report population-level estimates for <30 observations or relative SEs >30%.[46]

Analysis

Using descriptive statistics, we compared rates and temporal trends (2005–2015) in prolonged LOS between pediatric mental health and non–mental health ED visits. We then used survey-weighted logistic regression, examining the relationship between our 3 prolonged LOS outcomes, mental health versus non–mental health visits, and year. We used an interaction term to assess whether changes over time (by 1-year intervals) differed by mental health versus non–mental health visit. We adjusted for sex, age, payer type, race and ethnicity, and visit occurring during a school month (September to June).

We used survey-weighted logistic regression to examine the relationship between our 3 prolonged LOS outcomes and demographic and clinical visit characteristics. For demographic variables, we prespecified comparisons between Black non-Hispanic, Hispanic, and other race and ethnicity versus white non-Hispanic, as well as public and other payer type versus private payer. For clinical variables, we prespecified comparisons between visits with only mental health diagnoses versus visits with both physical and mental health diagnoses. We adjusted for age, sex, year, and school versus summer month. To statistically test whether trends over time differed between visits with only mental health diagnoses and visits with both physical and mental health diagnoses, we added an interaction term between year and type of mental health visit to the regression model.

Because of sample size constraints, we largely restricted our reported results to ED LOS >6 and >12 hours and limited reported results for ED LOS >24 hours to summary statistics.

To test the robustness of our findings using categorical ED LOS variables, we repeated each analysis using ED LOS as a continuous variable.

ED mental health visits resulting in admission or transfer often have longer LOS.[32] To assess whether differences in prolonged LOS might be explained by differences in disposition type, we compared mental health and non–mental health ED visits by disposition type and examined changes in disposition type over time.

All models were examined at the visit level by using survey sampling weights. Analyses were conducted by using R version 3.6.3.

RESULTS

We studied 36 125 records, which, after survey weighting, represent 149 975 479 pediatric ED visits between 2005 and 2015, 7 277 997 (4.9%) of which were mental health visits. Mental health visits had higher rates of prolonged LOS compared with non–mental health ED visits: 21.2% vs 4.8% >6 hours, 7.7% vs 1.2% >12 hours, and 1.9% vs 0.3% >24 hours. On average each year, 12 279 ED visits had an LOS >24 hours. Of mental health visits, 61% were white non-Hispanic, 20% were Black non-Hispanic, and 17% were Hispanic; 46% used a public payer and 35% used private insurance only; 62.4% had both mental health and physical health diagnoses associated with the visit and 37.6% had only mental health diagnoses associated with the visit (Table 1).

Between 2005 and 2015, rates of prolonged ED LOS remained stable for non–mental health visits but increased for mental health visits. From 2005–2006 to 2014–2015, the average annual rate of ED LOS >6 hours for mental health visits increased from 16.3% to 24.6%

TABLE 1 Characteristics of Pediatric Mental Health and Non–Mental Health Visits by Prolonged ED LOS (2005–2015)

	Mental Health Visits			Non–Mental Health Visits		
	Total, *n*	LOS >6, *n* (%)	LOS >12, *n* (%)	Total, *n*	LOS >6, *n* (%)	LOS >12, *n* (%)
All visits	7 277 997	1 539 414	561 278	142 697 482	6 793 349	1 718 164
Race and ethnicity						
White non-Hispanic	4 427 845	866 872 (56.3)	241 163 (43.0)	77 358 245	3 183 556 (46.9)	762 815 (44.4)
Black non-Hispanic	1 430 509	306 981 (19.9)	N/R	33 046 369	1 686 758 (24.8)	N/R
Hispanic	1 224 556	322 639 (21.0)	199 329 (35.5)	27 660 569	1 744 265 (25.7)	465 041 (27.1)
Other	195 087	N/R	N/R	4 632 299	N/R	N/R
Payer type						
Private	3 340 180	752 729 (48.9)	283 633 (50.5)	64 752 748	2 748 806 (40.5)	780 518 (45.4)
Public	2 515 057	476 346 (30.9)	119 393 (21.3)	52 952 825	2 518 046 (37.1)	502 109 (29.2)
Other	1 422 760	310 339 (20.2)	N/R	24 991 909	1 526 497 (22.5)	N/R
Type of diagnoses						
Mental and physical health	4 539 151	949 135 (61.7)	325 998 (58.1)	N/A	N/A	N/A
Mental health only	2 738 846	590 279 (38.3)	235 280 (41.9)	N/A	N/A	N/A
Age, y						
6–12	1 695 010	271 709 (17.7)	N/R	78 217 056	3 329 969 (49.0)	N/R
13–17	5 582 987	1 267 705 (82.3)	461 318 (82.2)	64 480 426	3 463 380 (51.0)	838 028 (48.8)
Sex						
Female	3 779 689	806 413 (52.4)	250 433 (44.6)	69 791 871	3 609 860 (53.1)	845 648 (49.2)
Male	3 498 308	733 001 (47.6)	310 845 (55.4)	72 905 611	3 183 489 (46.9)	872 516 (50.8)
School month						
No	1 062 387	225 124 (14.6)	N/R	22 420 533	1 071 082 (15.8)	N/R
Yes	6 215 610	1 314 290 (85.4)	462 045 (82.3)	120 276 949	5 722 267 (84.2)	1 410 754 (82.1)

All results represent weighted estimates. N/A, not applicable to visit sample; N/R, not reportable because of unreliable survey-weighted estimates (<30 unweighted observations or relative SEs >30%).

(441 542 visits) and from 5.3% (86 791 visits) to 12.7% (227 010 visits) for LOS >12 hours (Fig 2, Supplemental Table 4).

After adjusting for visit characteristics in regression analysis (Table 2), the odds of prolonged LOS were greater for mental health visits compared with non–mental health visits at each LOS outcome: a 3.3-times greater odds of LOS >6 hours (95% confidence interval [CI] 2.2–4.9) and a 2.9-times greater odds of LOS >12 hours (95% CI 1.3–6.2). Additionally, the interaction between mental health visit and year was statistically significant for LOS >6 hours (odds ratio [OR] 1.1; 95% CI 1.0–1.2) and LOS >12 hours (OR 1.15; 95% CI 1.0–1.3) revealing that the relationship between prolonged ED LOS and year differed by type of visit. Stratified models revealed a statistically significant and positive relationship between prolonged ED LOS and year for mental health visits but not for non–mental health visits (Supplemental Table 5).

Whereas a higher proportion of mental health visits resulted in admission or transfer (27.9%) compared with non–mental health visits (4.4%) (Supplemental Table 6, Supplemental Fig. 3), the distribution of disposition type did not change over time for mental health or non–mental health visits (Supplemental Fig. 4).

Regression analysis (Table 3) revealed that visits for Hispanic compared with white non-Hispanic children had increased odds of LOS >12 hours (OR 2.74; 95% CI 1.7–4.4). There was otherwise no statistically significant difference in prolonged LOS by race and ethnicity or payer type. After adding an interaction term to the model (Supplemental Table 7), there was a statistically significant relationship between LOS >12 hours and the interaction between year and type of mental health visit (OR 1.3; 95% CI 1.1–1.6), revealing that the relationship between prolonged ED LOS and year differed by type of mental health visit. Stratified models revealed a statistically significant and positive relationship between prolonged ED LOS and year for mental health visits with only mental health diagnoses but not for mental health visits with both mental and physical health diagnoses (Supplemental Table 8).

Repeating regression analyses by using ED LOS as a continuous as opposed to a categorical variable yielded similar results.

DISCUSSION

Over the 11-year study period, the odds of prolonged LOS for mental health ED visits were threefold greater and increased over time compared with non–mental health ED visits, which remained stable. Compared with white non-Hispanic children, Hispanic children had an increased risk of prolonged ED LOS. There was no difference in ED LOS by payer type. Additionally, the odds of prolonged ED LOS for visits with only mental health diagnoses increased over time in comparison with visits

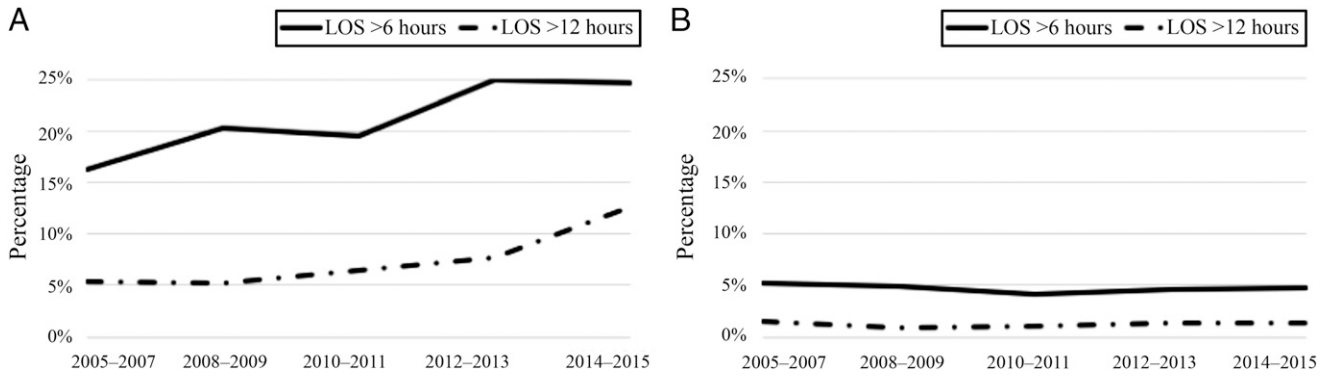

FIGURE 2

Trends over time in rates of prolonged ED LOS for pediatric mental health and non–mental health visits (2005–2015). All results represent weighted estimates. We were unable to report population-level estimates for visits with prolonged LOS >24 hours because of sample size. A, Mental health ED visits. B, Non–mental health ED visits.

with both mental and physical health diagnoses.

This study builds on previous literature suggesting that pediatric mental health ED visits are more vulnerable to prolonged LOS,[13–17,22,32–34] as well as recent literature indicating a rise in pediatric mental health ED visits over time, most notably from Kalb et al[9] and Lo et al,[54] who examine two different nationally representative data sets over the same time period as our study. Our study reveals that this increasing number of children seeking mental health care in the ED are also increasingly vulnerable to prolonged ED LOS. Although a higher percentage of mental health ED visits resulted in admission or transfer compared with non–mental health visits, the proportion of mental health visits resulting in admission or transfer did not change over time and thus cannot explain increasing rates of prolonged ED LOS for these visits. Although the etiology of prolonged ED LOS is likely multifactorial, the increasing rate of prolonged ED LOS over time, especially at the extremes of LOS >12 and >24 hours, likely represents worsening access to essential mental health services across the care continuum, namely, in the ED, inpatient, and outpatient settings. Concurrent with an increasing incidence of mental health conditions, over the past half century, the number of inpatient psychiatric beds has declined without compensatory expansion of outpatient services.[55–57] Mental health care for children is expensive, and suboptimal reimbursement limits incentives to expand services.[56] There continues to be a dearth of child psychiatrists and community supports.[3,58] EDs struggle to safely discharge children who present in crisis to appropriate care settings in light of limited services and poor coverage, which in turn leads to prolonged ED LOS.[59]

Although limited previous literature explicitly examines the association between ED LOS and race and ethnicity for mental health visits,[9,16,33] our study reveals that mental health ED visits for Hispanic patients have an increased odds of prolonged LOS compared with visits for white non-Hispanic patients. Further research should be used to explore etiologies of prolonged ED LOS for the Hispanic population, which likely include structural drivers of poor access to mental health care such as racism,[49,51,60–64] language barriers, fear of accessing care, and limited insurance coverage related to immigration status.[65,66] Individual institutions should examine their own ED LOS data to ensure equity for all children with mental health needs.

We were interested in the relationship between LOS and payer type, as an indicator of socioeconomic status and comparative access based on insurance. Previous literature reveals inconsistent results.[8,15,32] Our study revealed no significant difference in rates of prolonged ED LOS by payer type. Examining the relationship between payer type and ED LOS on a national level is

TABLE 2 Adjusted ORs of Prolonged ED LOS for Pediatric Mental Health Versus Non–Mental Health Visits and Year of Visit (2005–2015)

	LOS >6 h			LOS >12 h		
	aOR	95% CI	*P*	aOR	95% CI	*P*
Type of ED visit						
Non–mental health visit	Reference	Reference	Reference	Reference	Reference	Reference
Mental health visit	3.29	2.23–4.88	<.001	2.86	1.31–6.24	.009
Year[a]	0.99	0.96–1.02	.41	0.98	0.92–1.04	.53
Mental health visit × year	1.08	1.00–1.16	.04	1.15	1.02–1.30	.03

Adjusted for age, sex, payer type, race and ethnicity, and visit during school month. $P < .05$ is considered statistically significant. aOR, adjusted odds ratio.

[a] Year in 1-year intervals.

TABLE 3 Adjusted ORs of Prolonged ED LOS for Pediatric Mental Health Visits by Demographic and Clinical Characteristics (2005–2015)

	LOS >6 h			LOS >12 h		
	aOR	95% CI	*P*	aOR	95% CI	*P*
Race and ethnicity						
White non-Hispanic	Reference	Reference	Reference	Reference	Reference	Reference
Black non-Hispanic	1.11	0.69–1.79	.67	1.16	0.57–2.36	.68
Hispanic	1.36	0.94–1.97	.11	2.74	1.69–4.44	<.001
Other	1.19	0.53–2.67	.67	2.54	0.69–9.31	.16
Payer type						
Private	Reference	Reference	Reference	Reference	Reference	Reference
Public	1.17	0.83–1.66	.37	1.42	0.80–2.54	.23
Other	1.06	0.65–1.73	.82	1.74	0.78–3.89	.18
Type of diagnoses						
Mental and physical health	Reference	Reference	Reference	Reference	Reference	Reference
Mental health only	0.92	0.65–1.28	.61	1.39	0.85–2.27	.19
Age, y						
6–12	Reference	Reference	Reference	Reference	Reference	Reference
13–17	1.59	1.09–2.31	.02	1.54	0.79–3.02	.21
Sex						
Female	Reference	Reference	Reference	Reference	Reference	Reference
Male	1.03	0.75–1.41	.86	1.36	0.88–2.10	.16
School month						
No	Reference	Reference	Reference	Reference	Reference	Reference
Yes	1.01	0.64–1.60	.96	0.76	0.38–1.51	.43
Year[a]	1.07	1.00–1.13	.04	1.12	1.01–1.25	.03

$P < .05$ is considered statistically significant. aOR, adjusted odds ratio.

[a] Year in 1-year intervals.

challenging. Approximately 40% of children in the United States are covered by state-run Medicaid programs[67]; therefore, differences in coverage and reimbursement between private and public insurers vary by state. The Affordable Care Act mandated inclusion of mental health treatment under minimum standards for Medicaid coverage; however, states often define these mandated services differently. In some states, Medicaid might provide more comprehensive coverage for mental health care than private insurers, and in other states, less coverage is provided. Future analysis should be used to examine ED LOS among patients with Medicaid at the state level to understand variation in access.[68–70]

Previous literature reveals that a concurrent physical health diagnosis impacts use patterns in mental health visits.[12,45] We hypothesized that visits with both mental and physical health diagnoses would be associated with decreased rates of prolonged ED LOS because they would include presentations necessitating prompt admission to a medical unit, such as injuries or toxidromes secondary to attempts at self-harm. In contrast, the disposition and LOS for visits with only mental health diagnoses would be dictated by the mental health condition and associated with higher rates of prolonged ED LOS. We found that the rate of prolonged ED LOS for visits with only mental health diagnoses increased over time compared with visits with a concurrent physical health diagnosis, which supports our primary finding: for children requiring definitive access to mental health care, the rate of prolonged ED LOS is increasing over time.

During our study period and more recently, prolonged ED LOS for children with mental health conditions has become increasingly visible among the medical and lay community,[71,72] leading to promising changes at the health system and policy level.[42,43,47] However, there is still much to be done. Currently, the majority of EDs are not adequately resourced nor have written policies to care for children with mental health conditions.[23] Kalb et al[9] note that only 16% of children who presented to the ED for a mental health visit are seen by a mental health provider. Every ED should establish protocols, based on existing recommendations and tool kits,[73–77] that address pediatric mental health and secure 24-hour access to pediatric-trained mental health providers via in-person consultation or telepsychiatry.[78] ED staff should be trained in trauma-informed care, verbal de-escalation, pharmacologic, and when necessary, physical restraint for children. EDs with high volumes of pediatric mental health patients should consider dedicating space within or adjacent to the ED to ensure a therapeutic environment and to help manage throughput.[59] Furthermore, quality improvement programs that include root cause analyses and institution-specific interventions have the potential to improve care for children with mental health needs.[18,38]

Beyond the ED, inadequate access to mental health care for children must also be addressed through changes in state and federal policy.[18,36] High-profile court cases, such as in Washington State,[37,39] have resulted in significant local policy change and have motivated other states to pursue legislation protective against prolonged LOS.[40,79,80] Policy must address the shortage of providers[3,4] and expand coverage and reimbursement for the full spectrum of mental health services including inpatient treatment, community-based interventions, and integrated primary care and medical home models to ensure increased and equitable access to care across payer types.[44,59,81,82]

This study has limitations. First, NHAMCS collects data at the visit as opposed to at the patient level; therefore, we cannot assess the

impact of repeat visits. Second, sample size constraints and the quality of discharge diagnosis data limited more granular visit categorization and our ability to determine if a mental health diagnosis was the primary reason for visit or if there was a contributing comorbid condition or noncontributing but significant comorbid condition. Although the NHAMCS is a national database and our sample represents millions of ED visits, the relatively small number of mental health visits limited our ability to report accurate estimates for ED LOS >24 hours, as well as some subanalyses, such as stratification of regression models by disposition type. Because prolonged LOS and admission or transfer are likely related, it is possible that demographic characteristics associated with prolonged LOS actually represent predictors of admission or transfer. Further research should be used to explore characteristics associated with prolonged LOS, specifically for visits resulting in admission or transfer. Finally, the NHAMCS does not provide hospital location data beyond region. State-level data might have provided additional insight into the association between payer type and ED LOS.

CONCLUSIONS

Rates of prolonged ED LOS for pediatric mental health visits are increasing over time. Despite national attention to a pediatric mental health epidemic, our study suggests that timely and definitive access to mental health care for children is worsening. By 2014–2015, nearly 450 000 annual ED visits exceeded 6 hours and 227 010 visits exceeded 12 hours. Over the 11-year study period, 135 070 visits exceeded 24 hours. Vulnerability to prolonged ED LOS in mental health visits is not equitable: Hispanic patients have an almost threefold increased odds of prolonged LOS compared with white non-Hispanic patients. We found no difference in ED LOS by payer type; however, aggregate national data can obscure variation and important relationships at the state level. Although future research should be used to further explore drivers of prolonged LOS, we must address this crisis in access to acute mental health care for children through changes in our health care delivery systems, state policy, and federal policy.

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ABBREVIATIONS

CI: confidence interval
ED: emergency department
LOS: length of stay
NCHS: National Center for Health Statistics
NHAMCS: National Hospital Ambulatory Medical Care Survey
OR: odds ratio

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