Readmission After Pediatric Mental Health Admissions

ABSTRACT

Background: Reducing readmissions is a major health care system goal. There is a gap in our understanding of pediatric readmission patterns after mental health (MH) admissions. With this study, we aimed to characterize the prevalence of readmissions after MH admissions, to identify patient-level factors and costs associated with readmissions, and to assess variation in readmission rates across hospitals.

Methods: Using the 2014 Healthcare Cost and Utilization Project all-payer Nationwide Readmissions Database, we conducted a retrospective cohort analysis of 253,309 admissions for 5- to 17-year-olds at acute-care hospitals in 22 states. We calculated 30-day unplanned readmission rates, lengths of stay, and costs by primary admission diagnosis. We used hierarchical regression models to assess differences in readmission rates by patient characteristics, primary diagnoses, and comorbid chronic conditions, and to estimate the variation in case mix–adjusted rates across hospitals.

Results: MH stays accounted for 18.7% (n=47,397) of index admissions. The 30-day readmission rate for MH admissions was higher than for non-MH admissions (8.0% versus 6.2%; P<.001). Children who were ≤14 years old, had non-MH chronic conditions, and/or had public insurance were more likely to be readmitted than their peers (P<.001 for each). Adjusted rates varied across hospitals (P<.001) and were 97.9% greater for hospitals 1 standard deviation above versus below (11.2% vs 5.6%) the mean. Adjusted readmission rates, lengths of stay, and costs differed by diagnosis (P<.001).

Conclusions: The 30-day readmission rate was significantly higher after MH than non-MH admissions. Adjusted MH readmission rates varied substantially among hospitals, suggesting potential room for improvement.

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LIST OF TABLES AND FIGURES

ABBREVIATIONS

ADHD — attention-deficit/hyperactivity disorder

AHRQ — Agency for Healthcare Research and Quality

aOR — adjusted odds ratio

CCI — Chronic Condition Indicator

CI — confidence interval

HCUP — Healthcare Cost and Utilization Project

ICD-9-CM — International Classification of Diseases, Ninth Revision, Clinical Modification

MH — mental health

NRD — Nationwide Readmissions Database

SD — standard deviation

1. INTRODUCTION

Mental health (MH) conditions are among the most prevalent and costly health problems in the United States.[1, 2] One in five children has had a seriously debilitating mental disorder.[3] Children living with MH conditions experience substantial quality-of-life impairments, including interferences with family, peer, and school activities.[4] They tend to have lower educational attainment[5] and are more likely to commit self-harm.[6, 7] Undertreated MH conditions during childhood not only impose immediate costs on families and healthcare systems but also reduce lifetime earnings and increase long-term medical spending.[7-11] Psychiatric care constitutes a substantial and growing proportion of pediatric inpatient care utilization, accounting for 10% of all pediatric admissions and $3.3 billion in aggregate charges in 2014.[2, 12] In the last two decades, mood disorders alone have overtaken asthma as the most common reason for admission among children aged 1-17 years, with a 68% increase in the rate of mood disorder hospitalizations despite a 26% decrease in the overall hospitalization rate for the age group.[1, 2]

As a measure of quality of inpatient care, readmission rates have become a national focus.[13] Recurrent hospitalizations are disruptive for families[14-17] and a driver of cost to the healthcare system.[18-20] Targeting MH readmissions could reveal rich opportunities for quality improvement, as successful management of MH conditions is particularly predicated on longitudinal relationships outside the acute-care setting. However, the current National Quality Forum-endorsed pediatric all-condition measure, commissioned by the Agency for Healthcare Research and Quality (AHRQ) and Centers for Medicare & Medicaid Services, does not include hospitalizations for MH conditions.[21] Although questions have been raised as to whether MH conditions should be added, little is known about the prevalence or burden of pediatric MH readmissions.

To help prioritize opportunities to improve clinical practice and reduce readmissions, as well as to guide quality measure development, information is needed about which patient and clinical characteristics are associated with the most readmissions and how much readmission rates vary across hospitals. Variation in rates might signal modifiable community-, systems-, hospital-, and family-level levers for quality improvement.[22-24]

2. METHODS

2.1. Study Cohort

We conducted a retrospective cohort analysis of 5- to 17-year-olds who were discharged between 01/01/2014 and 11/30/2014 from 1,813 community hospitals in the AHRQ/Healthcare Cost and Utilization Project (HCUP) all-payer Nationwide Readmissions Database (NRD).[25] The dataset captures all discharges at nonfederal public and private hospitals in 22 geographically dispersed states that account for 51.2% of the total U.S. population and 49.3% of hospitalizations.

We started with all hospitalizations in the study date range for patients within the study age range, as well as hospitalizations that occurred between 12/1/2014 and 12/31/2014 and those for patients aged 18 years, in order to capture all readmissions for eligible index admissions (n=406,773). Records for multiple hospitalizations that included transfer to an acute care hospital were combined, and subsequent readmissions were attributed to the final discharging hospital. The primary diagnosis field of the final discharge record was used as the primary diagnosis of the episode, and all other diagnosis fields were retained as secondary diagnoses. We excluded patients with any records that contained a missing primary diagnosis (<0.1%; n=110). We excluded records related to obstetric conditions (15.0%; n=60,999), because labor and delivery does not generally fall within the purview of pediatric providers.[21, 22, 26, 27] We excluded index admissions for patients who were aged >17 years at discharge, left against medical advice, or died; for which 30 days of follow-up data were not available; or that occurred within 30 days of an eligible index admission, leaving 253,309 index admissions.

Because race/ethnicity was not available in the NRD, we conducted a sub-analysis using the 2014 AHRQ/HCUP New York State Inpatient Database, which included additional sociodemographic variables for the subset of NRD records from the hospitals in New York (Appendix A).[28]

We identified primary MH admissions using clinician-reviewed definitions that aggregate more than 200 MH-related ICD-9-CM diagnosis codes into 17 mutually exclusive categories based on the *Diagnostic and Statistical Manual of Mental Disorders, Fourth and Fifth Editions* (Appendix B).[2] Because the NRD does not contain information about the admitting service, the identified MH admissions reflect care provided on medical and psychiatric services of acute care hospitals.

2.2. Main Outcome Measures

We defined a readmission as the first unplanned admission within 30 days of an index admission. Any subsequent admissions that occurred within 30 days were not counted as either readmissions or new index admissions. Because a subject's hospitalizations could only be linked within a state, readmissions after an index admission in a different state were not compared.

We compared the prevalence of readmissions following MH index versus non-MH index admissions. For MH index admissions, we estimated differences in readmission rates by patient and clinical characteristics, as well as variation in rates among hospitals. We included unplanned readmissions for any reason because patients might have been readmitted for related conditions even if the index and readmission diagnoses differ, but we also conducted an analysis of readmissions with diagnoses matching those of index admission. To exclude planned readmissions, we used the Pediatric Planned Procedures Algorithm, as described below,[21-23, 26, 27] in addition to excluding readmissions with a primary procedure or diagnosis code for chemotherapy.[21-23, 26, 27] These admissions are usually part of the patient’s intended course unrelated to quality. Mean lengths of stay and costs were calculated for the first unplanned 30-day readmission, as previously described.[29]

2.3. Unplanned Readmissions

To exclude planned readmissions, we used the Pediatric Planned Procedures Algorithm developed by the Center of Excellence for Pediatric Quality Measurement at Boston Children’s Hospital for the Pediatric All-Condition and Lower Respiratory Infection Readmission Measures.[21-23, 26, 27] The algorithm identifies ICD-9-CM codes for procedures designated by pediatric specialists as scheduled in advance in >80% of cases and potentially the reason for a hospitalization. Any readmission that contained an identified procedure code was classified as a planned readmission.

2.4. Patient and Clinical Characteristics

We assessed associations of readmission rates with patient sociodemographic (gender, age, insurance status) and clinical (primary diagnosis, comorbid chronic conditions) characteristics, which were chosen *a priori* based on previous studies.[21-23, 26, 27] Insurance status was categorized as public, private, self-pay, and other. We used the Chronic Condition Indicator (CCI) to dichotomize ICD-9-CM diagnosis codes into chronic or non-chronic conditions and aggregate conditions into 18 mutually exclusive groups (e.g., cardiovascular).[30] The number of non-MH CCI groups for each index admission served as an indicator of medical complexity.[21-23, 26, 27]

2.5. Statistical Analyses

To model readmission rate, we estimated hierarchical regression models with random effects for hospital and fixed-effect predictors for patient, clinical, and/or hospital characteristics.

To compare overall readmission rates following MH and non-MH index admissions, we estimated the effect of an MH condition as the primary diagnosis, adjusting for gender, age, and the number of non-MH CCIs.

To assess differences in MH readmission rates by patient and clinical characteristics, we conducted separate bivariate analyses to predict MH readmissions from each characteristic. Characteristics associated with readmission with $P<.20$ in bivariate analysis were entered simultaneously into a multivariate model. Block tests with multiple degrees of freedom were used to determine the significance of each fixed effect with more than two levels.

To calculate case-mix-adjusted hospital readmission rates, we adjusted for gender, age, primary MH diagnosis, and number of comorbid chronic conditions. Adjusted readmission rates were calculated by averaging predicted rates from case-mix regression models in which the hospital variable was fixed and observed values from the entire population were used for the remaining independent variables (Appendix B).[21-23, 26, 27] Variation in adjusted readmission rates was quantified by the hospital-level random-effect variance in the regression model. Likelihood ratio tests were used to determine the significance of the random-effect estimate.

To estimate adjusted costs and lengths of stay by primary diagnosis, we calculated predictive margins from hierarchical gamma and negative binomial regressions, respectively, accounting for gender, age, and number of non-MH CCIs.

In all analyses, we calculated robust standard errors and two-sided tests at level .05 using SAS 9.4 and Stata 14.1. Boston Children's Hospital's Institutional Review Board approved the study

2.6. Sensitivity Analyses

To test the robustness of the readmission rate analyses, we assessed the effects of including additional hospital-level covariates as fixed effects, as well as using alternative time windows for readmission.

Because hospitals that provide more MH care might care for patients with more severe MH conditions that might not be captured in the case-mix model, we also assessed rates separately for hospitals in the top decile for volume (*n*>420) or proportion (>75%) of MH admissions. Because the availability of psychiatric services (e.g., number of psychiatric beds) cannot be determined using the NRD, we tested other hospital characteristics such as overall bed size, teaching status, and urban-rural designation of hospitals as indirect measures to resource availability. Bed-size categories were determined as per HCUP specifications.[31] Urban-rural designation was based on the Urban Influence Codes. Each hospital-level factor was added individually as fixed effects to the case-mix adjustment model. Significance of each covariate was determined as above.

The time window of readmissions is at times raised as a concern of measure validity. An overly narrow timeframe may inadequately capture the entire time period during which an adverse event could occur, while a broad timeframe may increase the risk of capturing admissions unrelated to care given during the index admission. We therefore assessed other readmission follow-up periods of 7, 14, and 60 days after the index admission. We estimated the amount of hospital-level variation estimated for each timeframe and compared them with that under the 30-day criterion using likelihood ratio tests of the hospital random-effect estimates.

3. RESULTS

3.1. Study Cohort

Among 253,309 index admissions, 18.7% were for a primary MH diagnosis (*n*=47,397). The median age among MH patients was 15 years (interquartile range, 13-16). Sixty-four percent had no non-MH comorbid chronic conditions, 26.3% had 1 CCI group, and 10.0% had conditions in 2 or more CCI groups (Table 1). The most common non-MH CCIs were respiratory diseases (*n*=7,656; 16.2%) and endocrine disorders (*n*=5,772; 12.2%).

The unadjusted 30-day unplanned readmission rate for MH admissions was 8.0% (*n*=3,783), which was higher than the rate of 6.2% (*n*=12,781) for non-MH admissions (P<.001). This difference remained significant after adjusting for age, gender, and number of non-MH CCIs (P<.001).

3.2. Index Admission Diagnoses

Table 1 shows the 10 most prevalent MH primary diagnoses, which accounted for 98.7% of all MH index admissions. Mood disorders were the most common, with depression and bipolar disorders accounting for 60.0% and 10.9% of admissions, respectively. Externalizing disorders constituted 6.5% of admissions, most of which were for oppositional defiant disorders (38.7%), impulse-control disorders (31.9%), and conduct disorders (29.1%). Other of the most common diagnoses included reaction disorders (5.8%), psychosis (4.9%), anxiety disorders (4.5%), attention-deficit/hyperactivity disorder (ADHD) (3.2%), autism spectrum disorder (1.0%), eating disorders (1.0%), and substance-related disorders (0.9%).

3.3. Readmission Rates by Patient and Clinical Characteristics

In bivariate analysis, MH readmission rates varied significantly by gender, age, comorbid chronic conditions, primary diagnosis, and insurance type (P=.03 for gender; P<.001 for other block tests) (Table 1). Except for gender (P=.60), all other bivariately significant adjusters remained significant in multivariate analysis (P<.001 for each). Compared with 15- to 17-year-olds, younger children were more likely to be readmitted. Readmission rates increased with the number of comorbid chronic conditions: 8.3% for 1 non-MH CCI (adjusted odds ratio (aOR) 1.11; 95% confidence interval (CI), 1.03-1.20) and 8.9% for ≥2 non-MH CCIs (aOR 1.22; 95%

CI, 1.09-1.36), compared with children with no comorbid chronic conditions (7.7%). By primary diagnosis, rates were higher for psychosis (11.6% [aOR 1.60; 95% CI, 1.39-1.84]) and bipolar disorders (9.9% [aOR 1.33; 95% CI, 1.20-1.49]) than for depression (7.7%). Rates were lower for reaction disorders (5.2% [aOR 0.58; 95% CI, 0.48-0.70]) and substance-related disorders (2.7% [aOR 0.38; 95% CI, 0.21-0.68]) than for depression. Children with public insurance (8.7% [aOR 1.20; 95% CI, 1.11-1.29]) were more likely to be readmitted than children with private insurance (7.0%).

In a sub-analysis of 8,737 admissions at New York State hospitals, race/ethnicity was significantly associated with readmission rates bivariately ($P<.001$) and multivariately ($P=.01$) (Table A-1). Rates were higher for children who were non-Hispanic Black (10.6%; $P=.001$) and Hispanic (10.1%; $P=.006$) than for White children (6.9%), adjusting for age, primary MH diagnosis, the number of comorbid non-MH conditions, and insurance type.

3.4. Hospital-Level Variations in Readmission Rates

Unadjusted readmission rates following index hospitalizations for all MH conditions varied significantly among hospitals ($P<.001$), and this variation persisted after case-mix-adjustment ($P<.001$). Among the 112 hospitals in the top quartile of MH index admissions ($n>80$), adjusted rates were significantly below the mean for 14 hospitals and above the mean for 11 hospitals (Figure 1).

To illustrate the magnitude of variation among hospitals, we compared the rates predicted for hypothetical hospitals with random effects 1 standard deviation (SD) above and below the mean (Figure 2). The adjusted all-condition rate of 11.2% for hospitals 1 SD above the mean was twice the rate of 5.6% for hospitals 1 SD below the mean. Unadjusted condition-specific readmission rates varied significantly among hospitals for five of the ten most prevalent diagnoses ($P<.001$ for depression, bipolar disorders, externalizing disorders; $P=.007$ for psychosis; and $P=.047$ for reaction disorders). Variation remained significant for the five diagnoses after adjusting for gender, age, and comorbid chronic conditions ($P<.001$ for each, except $P=.009$ for psychosis and $P=.04$ for reaction disorders).

3.4.1. Sensitivity Analyses

Readmission rates at hospitals with high volumes or proportions of MH admissions did not differ significantly from hospitals with lower volumes (*P*=.13) or proportions (*P*=.88) of MH admissions. Adjusted rates varied significantly among hospitals with high volumes and among hospitals with high proportions of MH admissions (*P*<.001 for each). Readmission rates also did not differ significantly by hospital-level characteristics, including overall bed size (*P*=.17), teaching status (*P*=.87), and urban-rural designation of hospital (*P*=.87).

Unadjusted and adjusted readmission rates varied significantly across hospitals when the readmission follow-up period was redefined to 7, 14, or 60 days after the index admission (*P*<.001 for each). In all cases, the amount of variation did not differ significantly from what was observed at 30 days.

3.5. Readmission Diagnoses

Of children readmitted within 30 days of an MH admission, 94.8% (*n*=3,588) were readmitted for a MH primary diagnosis. MH was the most common primary readmission diagnosis for each of the 10 most prevalent conditions. Fluid and electrolyte disorders and poisoning were the most common non-MH readmission diagnosis following admissions for eating disorders and substance-related disorders, respectively.

3.6. Readmission Lengths of Stay

The mean readmission length of stay for all MH conditions, adjusted for gender, age, and number of comorbid chronic conditions, was 7.4 days (95% CI, 6.6-8.2). Adjusted lengths of stay varied significantly by primary diagnosis and across hospitals (*P*<.001 for both) (Table 2). Conditions with the longest adjusted lengths of stay included psychosis (10.3 days; 95% CI, 9.0-11.8) and ADHD (9.6 days; 95% CI, 8.1-11.3). Readmissions following admissions for substance-related disorders (3.8 days; 95% CI, 2.3-6.3) and reaction disorders (6.4 days; 95% CI, 5.5-7.6) had the shortest lengths of stay.

3.7. Readmission Costs

Adjusted per-readmission costs, which averaged $6,781 (95% CI, $5,998-$7,667) across all MH conditions, varied significantly by index admission diagnosis and among hospitals

(*P*<.001 for each). Conditions with the highest readmission cost included psychosis ($9,024; 95% CI, $7,822-$10,411) and anxiety disorders ($8,447; 95% CI, $7,175-$9,945). Substance-related disorders ($4,727; 95% CI, $3,060-$7,301) and reaction disorders ($5,626; 95% CI, $4,770-$6,635) had the lowest per-readmission costs.

4. DISCUSSION AND CONCLUSIONS

In a large national cohort of hospitals, 8.0% of children admitted for MH conditions experienced an unplanned 30-day readmission, compared with 6.2% of those hospitalized for non-MH conditions. The rate, length of stay, and cost of readmissions varied across specific MH diagnoses, and all three measures were high for psychosis and low for reaction and substance-related disorders. Readmission rates also varied significantly among hospitals after adjusting for case-mix differences.

Previous research has shown that readmission rates are associated with a child's age,[20, 22, 32] medical complexity,[20, 22, 32-35] race/ethnicity,[20, 22, 32] and insurance status,[20, 22, 32, 34, 36-38] but no large cohort study has focused on pediatric MH patients. In our study, we found that MH readmissions were less frequent for patients in late adolescence than for those who were younger, in contrast to prior studies that showed increasing all-condition readmissions with age. This difference could reflect the inverse relationship between severity and age of onset for some conditions, as well as increased need for inpatient stabilization closer to time of onset.[39] We found that Black and Hispanic children were more likely to be readmitted than White children, a disparity not readily explained by differences in age, MH diagnosis, the number of coexisting chronic conditions, or insurance status. Our work adds to a large body of evidence indicating health disparities, which are important to understand for quality improvement and policymaking purposes.[40-42]

We found, as in all-condition readmission studies,[20, 22, 32-35] that readmission utilization and cost were higher for patients who were more medically complex, which included those with more co-morbidities and those with conditions that typically require higher-intensity care, such as psychosis.[2] Nonetheless, for many of the most common MH diagnoses, substantial hospital variation in readmission rates remained after adjusting for the relative mix of patient complexity at each hospital.

The variation that we found in MH readmission rates suggests likely room for improvement. Central to the debate regarding readmissions is the issue of attribution. Further research should explore the reasons for variation and the degree to which readmissions are preventable. Hospital-level variation could reflect disparities at each stage of care. First, variation may reflect differences in care during the initial hospitalization. For example, lower quality of discharge planning has been linked with frequent readmissions.[43-46] Patients without outpatient appointments in place before discharge from a psychiatric hospitalization were twice as likely to be readmitted within the same year.[47] Second, variation may reflect differences in post-discharge care. For example, receipt of outpatient therapy and appropriate medication regimens could be protective against readmissions.[48-50] Primary care physicians of publicly insured and uninsured patients reported more difficulties accessing outpatient MH services due to lack of provider options and longer wait times.[51, 52] As in prior studies, we found that children with public insurance were more likely to be readmitted. Third, variation may reflect differences in community factors. From a structural standpoint, accessibility of public transportation,[53] availability of paid family leave,[54, 55] and geographic distribution of hospital beds can affect care access.[56] From a family standpoint, cultural attitudes toward MH could influence engagement in care,[40, 57, 58] and difficult family dynamics are associated with higher inpatient use.[59]

On average, children readmitted after MH admissions were hospitalized for more than a week. Recurrent lengthy hospital stays not only place additional stress on families, but also increase children's exposure to harms of inpatient stays (e.g., nosocomial infections).[19] Frequent discontinuities in their environment might be particularly deleterious to children with certain MH disorders.[60] From a systems perspective, the high prevalence of MH admissions and long lengths of stay on readmission make inpatient MH care an important target for measurement and potential quality improvement.

One criticism of readmissions measures has been that relatively few readmissions seem to be related to the index admission.[22, 61] In contrast, we found that <1 in 10 MH readmissions were for non-MH primary diagnoses, and many non-MH diagnoses were nevertheless likely clinically related (e.g., readmissions for electrolyte derangements in patients with eating disorders). The specificity of readmissions at capturing related events may make them particularly suitable for quality measurement.

4.1. Limitations

Our study has several limitations. First, our data do not distinguish admission to psychiatric versus general medicine services and do not include specialty psychiatric hospitals. Future research should ascertain whether children receive adequate MH care or experience differential readmission risk when admitted to general medicine services, especially as inpatient psychiatric beds become increasingly scarce.[62, 63] Second, our study is limited to inpatient care. We could not assess receipt or quality of outpatient care, which has been associated with readmission risk.[43, 45] Further research is needed to investigate the degree to which outpatient care explains variation in readmission rates. Third, the Nationwide Readmissions Database is limited to discharges from general acute-care hospitals, thereby undercounting patients readmitted to specialty inpatient psychiatric hospitals. The database also does not allow tracking of patients across states, possibly leading to underestimation of readmissions to out-of-state hospitals. Fourth, the dataset does not disclose geographic details of hospitals, limiting our ability to model state-level effects, which might be important given interstate variations in public insurance.[37] Lastly, some primary MH diagnoses might represent undiagnosed non-MH conditions. For example, autoimmune encephalitis or epilepsy could underlie psychosis,[64] and lead poisoning or cardiac arrhythmias can manifest as pathologic anxiety.[65] In such cases, readmission patterns would not necessarily reflect the quality of MH care.

4.2. Suggestions for Future Work

The variation that we found in MH readmission rates suggests likely opportunities for improvement, but more work is needed to better characterize the extent to which readmissions are preventable and to whom excess readmissions are attributable. Further work should aim to understand drivers of variation in readmission rates, which might reveal community-, systems-, hospital-, and family-level levers for quality improvement. Associations of readmission rates with hospital characteristics (e.g., availability of specialty MH services, children's versus non-children's hospital) may highlight those institutions that may most benefit from quality improvement efforts. Differences in post-discharge factors (e.g., accessibility of outpatient MH services, quality of outpatient MH services) may signal room for systems-level improvement. Isolating differences by structural factors (e.g., availability of transportation, availability of paid family leave) could direct policy efforts. Differences by cultural factors (e.g., cultural attitudes towards MH) could guide education efforts.

Longitudinal trend of MH readmissions could provide additional insights. For example, readmission rates may paradoxically increase while institutions work to reduce all admissions. As the average acuity of all admissions increases as low-acuity admissions are avoided, readmission rates may increase despite reduction in absolute inpatient use. Analysis across multiple years of both MH admissions and readmissions could be useful to better understand this phenomenon and avoid penalizing overall quality improvement.

A potential barrier to operationalizing a pediatric MH readmission measure is the limited patient volume at certain general acute hospitals. Two potential approaches could be considered and are worth further exploration. First, data from multiple years could be used to assess the performance of lower-volume hospitals, although using multiple years of data would decrease the ability to demonstrate change from year to year. More work is needed to assess the potential tradeoff between measurement accuracy and the measure's responsiveness to hospital behavior. Second, MH could be integrated into all-condition measures. More work is needed to determine whether this could dampen our ability to detect strong- and poor-performing institutions.

For readmission measures more generally, there is ample room to improve the robustness of case-mix adjustment models. Readmission measures have historically been based on claims data, which is in part motivated by the immense administrative burden of approaches such as chart extraction. Future work should focus on incorporating more modern techniques such as natural language processing and machine learning to enrich understanding of individual patients beyond what is available in administrative claims including clinical data and documentation. The ability to disseminate sensitive medical record information while respecting patient privacy will be an important challenge in quality measurement design.

5. SUMMARY

MH readmissions generally had long lengths of stay with high likelihood of being related to the initial admission, and readmission rates varied significantly across hospitals in excess of case-mix differences. Given their prevalence and substantial hospital-level variation, MH readmissions might be a useful measure of quality. Our study offers insight into factors associated with readmissions and which conditions incur the highest utilization and cost burden, which could help prioritize specific targets for quality improvement.

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8. TABLES AND FIGURES

Table 1. Thirty-Day Mental Health Readmission Rates by Patient Characteristics

Characteristics	Index Admissions No. (%) (*n*=47397) [a]	30-Day Readmissions			
		No.	Rate, %	Bivariate Odds Ratio (95% CI) [b]	Multivariate Odds Ratio (95% CI) [c]
Gender					
Male	20157 (42.5)	1688	8.4	1.08 (1.01-1.15)	1.02 (0.95-1.09)
Female	27240 (57.5)	2095	7.7	Reference	Reference
Age					
5-8 years	2540 (5.4)	211	8.3	1.22 (1.05-1.42)	1.22 (1.04-1.43)
9-12 years	8115 (17.1)	816	10.1	1.49 (1.36-1.63)	1.48 (1.35-1.63)
13-14 years	12816 (27.0)	1076	8.4	1.23 (1.13-1.33)	1.24 (1.14-1.34)
15-17 years	23926 (50.5)	1680	7.0	Reference	Reference
No. of Non-MH CCIs [d]					
≥2	4733 (10.0)	422	8.9	1.25 (1.12-1.40)	1.22 (1.09-1.36)
1	12450 (26.3)	1037	8.3	1.14 (1.05-1.23)	1.11 (1.03-1.20)
None	30214 (63.7)	2324	7.7	Reference	Reference
Primary Diagnosis [e]					
Depression	28437 (60.0)	2187	7.7	Reference	Reference
Bipolar disorders	5169 (10.9)	513	9.9	1.34 (1.21-1.50)	1.33 (1.20-1.49)
Externalizing disorders	3074 (6.5)	264	8.6	1.11 (0.96-1.27)	1.00 (0.87-1.15)
Reaction disorders	2740 (5.8)	142	5.2	0.58 (0.48-0.70)	0.58 (0.48-0.70)
Psychosis	2324 (4.9)	269	11.6	1.56 (1.36-1.79)	1.60 (1.39-1.84)
Anxiety disorders	2136 (4.5)	140	6.6	0.86 (0.72-1.03)	0.82 (0.69-0.99)
Attention-deficit/hyperactivity disorder	1506 (3.2)	138	9.2	1.15 (0.96-1.39)	1.01 (0.83-1.23)
Autism spectrum disorder	484 (1.0)	44	9.1	1.25 (0.91-1.72)	1.14 (0.83-1.56)
Eating disorders	474 (1.0)	39	8.2	1.12 (0.80-1.58)	1.09 (0.77-1.54)
Substance-related disorders	446 (0.9)	12	2.7	0.33 (0.19-0.60)	0.38 (0.21-0.68)
Other MH diagnoses	607 (1.3)	35	5.8	0.79 (0.56-1.12)	0.73 (0.51-1.03)
Insurance [f]					
Public	26264 (55.5)	2281	8.7	1.26 (1.17-1.36)	1.20 (1.11-1.29)
None	1102 (2.3)	61	5.5	0.75 (0.58-0.98)	0.78 (0.60-1.02)
Other	2307 (4.9)	194	8.4	1.12 (0.94-1.32)	1.11 (0.94-1.31)
Private	17653 (37.3)	1242	7.0	Reference	Reference

[a] Mental health was the primary diagnosis of 47,397 (18.7%) of 253,309 index admissions.

[b] To assess whether readmission rates varied by each patient characteristic, *P* value from multiple degrees of freedom block test on all categories of each characteristic was calculated from a hierarchical logistic regression model with fixed effect for the characteristic and random effect for hospital. *P*=.03 for block test of gender, and *P*<.001 for block tests of all other characteristics in bivariate analysis.

[c] Adjusted odds ratio from hierarchical logistic regression model with random effect for hospital and fixed effects for all characteristics that were significant in bivariate analysis with $P<.20$. $P=.60$ for block test of gender, and $P<.001$ for block tests of all other characteristics in multivariate analysis.

[d] The Chronic Condition Indicators (CCIs), developed by the Agency for Healthcare Research and Quality, categorize approximately 14,000 ICD-9-CM diagnosis codes as chronic or not chronic and assign codes into one of 18 mutually exclusive body system groups.

[e] Other MH diagnoses include personality, reactive attachment, motor, elimination, developmental, and sexual/gender identity disorders, each accounting for <1% of MH admissions.

[f] Index admissions with missing insurance type (0.1%, $n=71$) were excluded in the respective bivariate analysis and in the multivariate model.

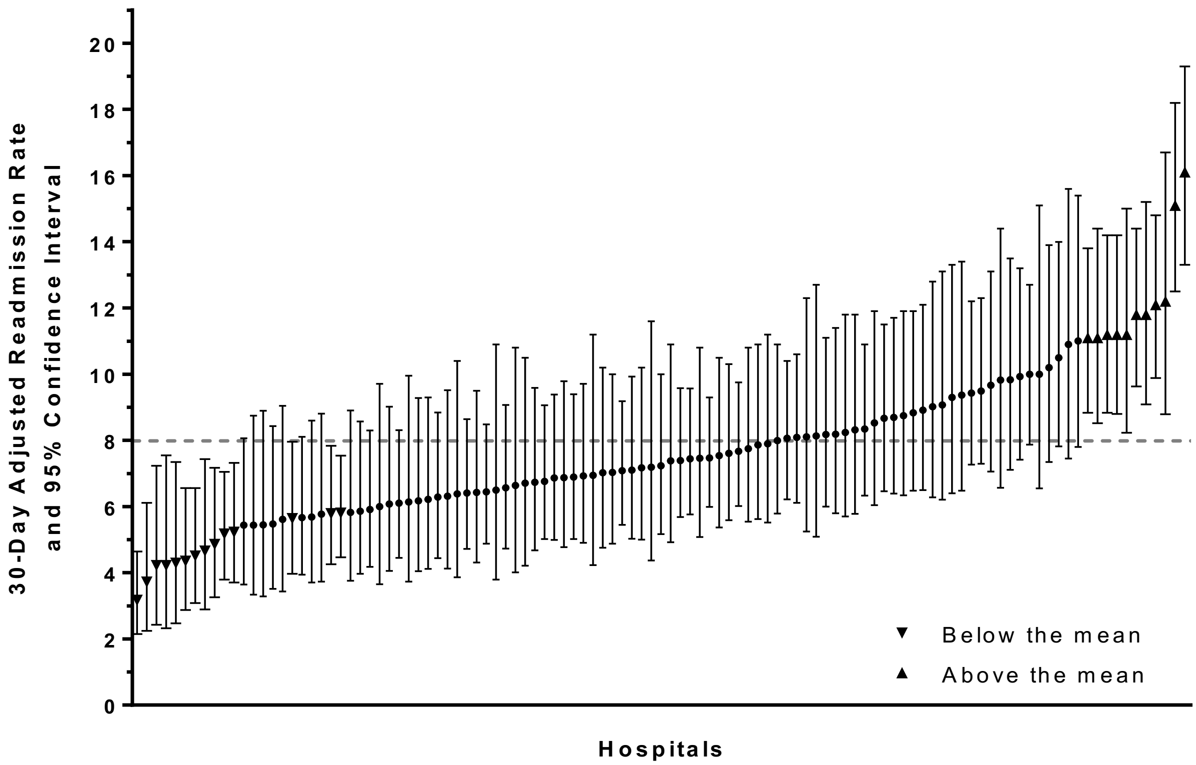
Table 2. Adjusted Length of Stay and Cost of 30-Day Mental Health Readmissions

Primary Diagnosis	30-Day Readmission [a]	
	Mean Length of Stay, $ (95% CI)	**Mean Cost, $ (95% CI) [b]**
Psychosis	10.3 (9.0-11.8)	9024 (7822-10411)
Attention-deficit/hyperactivity disorder	9.6 (8.1-11.3)	7707 (6522-9108)
Bipolar disorders	8.7 (7.7-9.7)	7319 (6429-8332)
Anxiety disorders	8.2 (7.0-9.7)	8447 (7175-9945)
Eating disorders	8.1 (6.1-10.8)	7652 (5698-10278)
Autism spectrum disorder	7.9 (6.2-10.2)	6956 (5452-8874)
Externalizing disorders	7.4 (6.5-8.5)	6238 (5414-7186)
Depression	7.2 (6.5-8.0)	6206 (5526-6971)
Reaction disorders	6.4 (5.5-7.6)	5626 (4770-6635)
Substance-related disorders	3.8 (2.3-6.3)	4727 (3060-7301)
Other mental health diagnoses	5.7 (4.2-7.6)	5919 (4435-7901)
All mental health conditions	7.4 (6.6-8.2)	6781 (5998-7667)

[a] Adjusted mean length of stay and cost per readmission were estimated as marginal predictions from negative binomial and gamma regression models, respectively, using the overall cohort distributions of gender, age, and number of non-mental-health comorbid chronic conditions. Length of stay and cost were significantly associated with primary diagnosis (P<.001 for each block test).

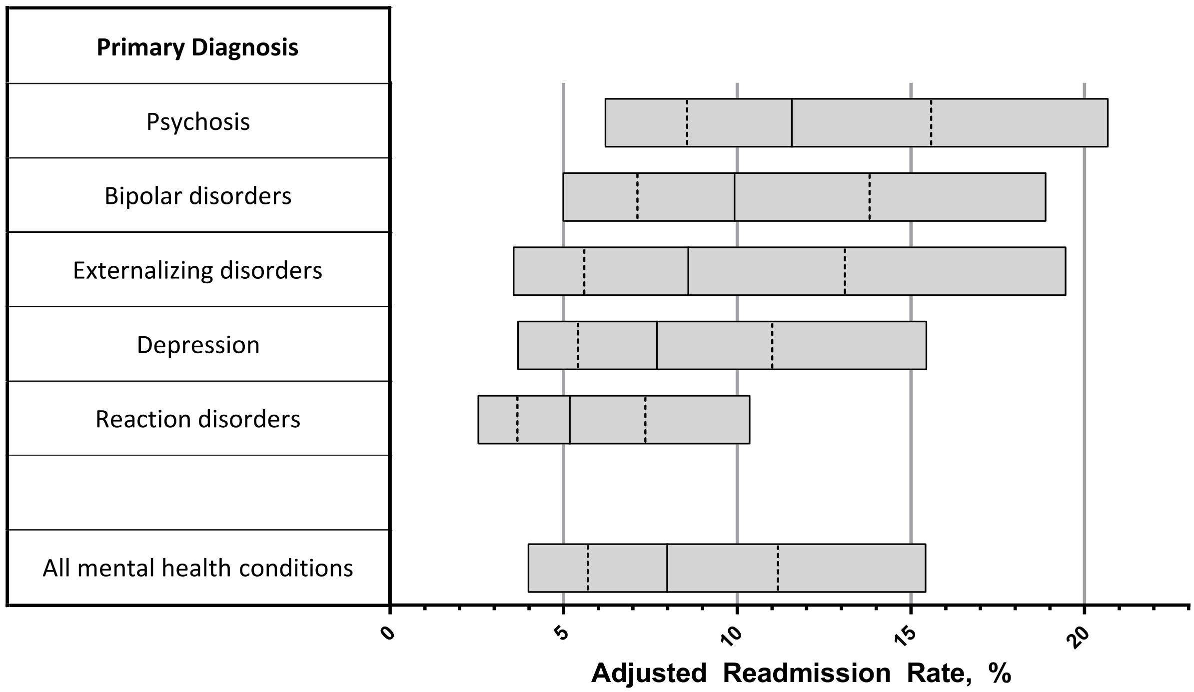
[b] Cost could not be estimated due to missing data for 64 (1.8%) readmissions.

Figure 1. Variation in Adjusted 30-Day Mental Health Readmission Rates



Adjusted 30-day readmission rate variation among hospitals in the top quartile of MH index admissions. The 112 hospitals in the top quartile of mental health index admissions (*n*>80) were included. Significant variation in readmission rates existed after adjusting for gender, age, primary diagnosis, and number of non-mental-health comorbid chronic conditions (*P*<.001). Dashed line indicates the mean unadjusted readmission rate.

Figure 2. Variation in Adjusted Condition-Specific 30-Day Readmission Rates



Adjusted readmission rates for hospitals 1 or 2 standard deviations (SD) above and below the mean were estimated for mental health conditions with significant hospital-level variation, using hierarchical logistic regressions that accounted for gender, age, and number of non-MH comorbid chronic conditions. $P<.001$ for each condition, except $P=.009$ for psychosis and $P=.04$ for reaction disorders. Adjusted all-condition readmission rates were similarly calculated with additional adjustment for primary diagnosis. Solid line through the middle of each box indicates mean rates; dotted lines, +/-1 SD of the mean; box boundaries, +/-2 SD.

APPENDIX A. SUBANALYSIS OF RACIAL/ETHNIC DIFFERENCES

In order to evaluate racial/ethnic differences in MH readmission rates, we conducted a sub-analysis of hospitals in New York State. Additional sociodemographic variables, not available in the NRD, were derived from the 2014 AHRQ/HCUP New York State Inpatient Database.[28]

We conducted a separate retrospective cohort analysis of 5- to 17-year-olds who were discharged between 01/01/2014 and 11/30/2014 from 157 community hospitals in New York State. We started with all hospitalizations in the study date range for patients within the study age range, as well as hospitalizations that occurred between 12/1/2014 and 12/31/2014 and those for patients aged 18 years, in order to capture all readmissions for eligible index admissions (*n*=76,182). Records for multiple hospitalizations that included transfer to an acute care hospital were combined, and subsequent readmissions were attributed to the final discharging hospital. The primary diagnosis field of the final discharge record was used as the primary diagnosis of the episode, and all other diagnosis fields were retained as secondary diagnoses. We excluded records related to obstetric conditions (7.9%; *n*=5,995), because labor and delivery does not generally fall within the purview of pediatric providers.[21, 22, 26, 27] We excluded index admissions for patients who were aged >17 years at discharge, left against medical advice, or died; for which 30 days of follow-up data were not available; or that occurred within 30 days of an eligible index admission, leaving 51,922 index admissions.

A.1. Study Cohort

Among 51,922 index admissions, 16.8% were for a primary MH diagnosis (*n*=8,737). The median age among MH patients was 14 years (interquartile range, 12-16). Sixty-one percent had no non-MH comorbid chronic conditions, 29.3% had conditions in 1 CCI group, and 9.9% had conditions in 2 or more CCI groups (Table A-1). The most common non-MH CCIs were respiratory diseases (*n*=1,687; 19.3%) and endocrine disorders (*n*=1,250; 14.3%).

The unadjusted 30-day unplanned readmission rate for MH admissions was 8.7% (*n*=759), which was higher than the rate of 6.0% (*n*=2,608) for non-MH admissions ($P<.001$). This difference remained significant after adjusting for age, gender, and number of non-MH CCIs ($P<.001$).

A.2. Index Admission Diagnoses

Table A-1 shows the 10 most prevalent MH primary diagnoses, which accounted for 98.1% of all MH index admissions. Mood disorders were the most common, with depression and bipolar disorders accounting for 53.8% and 9.5% of admissions, respectively. Externalizing disorders constituted 9.0% of admissions, most of which were for impulse-control (44.3%), oppositional defiant (30.1%), and conduct disorders (25.3%).

A.3. Readmission Rates by Patient and Clinical Characteristics

Except for gender (*P*=.35), MH readmission rates varied significantly, in bivariate analysis, by age, comorbid chronic conditions, primary diagnosis, race/ethnicity, and insurance type (*P*=.004 for primary diagnosis, *P*=.01 for insurance; *P*<.001 for others) (Table A-1). Except for insurance (*P*=.50), all other bivariately significant adjusters remained significant in multivariate analysis (*P*=.01 for primary diagnosis, *P*=.01 for race/ethnicity; *P*<.001 for others).

Children aged 9-12 years (11.6% [aOR 1.46; 95% CI, 1.19-1.78]) were more likely to be readmitted than those aged 15- 17 years (7.8%). Readmission rates increased with the number of comorbid chronic conditions: 9.7% for 1 non-MH CCI (aOR 1.27; 95% CI, 1.07-1.50) and 12.4% for ≥2 non-MH CCIs (aOR 1.70; 95% CI, 1.35-2.15), compared with children with no comorbid chronic conditions (7.6%). By primary diagnosis, rates were higher for psychosis (12.2% [aOR 1.50; 95% CI, 1.14-1.96]) than for depression (8.2%).

Rates were higher for children who were non-Hispanic Black (10.6% [aOR 1.40; 95% CI, 1.14-1.72]] and Hispanic (10.1% [aOR 1.38; 95% CI, 1.10-1.74] than for White children (6.9%). While children with public insurance were more likely to be readmitted than those with private insurance in bivariate analysis, this difference did not persist after adjusting for age, number of comorbid chronic conditions, primary diagnosis, and race/ethnicity.

Table A-1. Thirty-Day Mental Health Readmission Rates in New York State

Characteristics	Index Admissions No. (%) (*n*=8737) [a]	30-Day Readmissions			
		No.	Rate, %	Bivariate Odds Ratio (95% CI) [b]	Multivariate Odds Ratio (95% CI) [c]
Gender				*P*=.35	
Male	3723 (42.6)	338	9.1	1.08 (0.92–1.25)	
Female	5014 (57.4)	421	8.4	Reference	
Age				*P*<.001	*P*<.001
5-8 years	547 (6.3)	42	7.7	0.95 (0.68–1.33)	0.91 (0.64–1.31)
9-12 years	1684 (19.3)	195	11.6	1.51 (1.25–1.83)	1.46 (1.19–1.78)
13-14 years	2321 (26.6)	194	8.4	1.07 (0.89–1.29)	1.07 (0.89–1.30)
15-17 years	4185 (47.9)	328	7.8	Reference	Reference
No. of Non-MH CCIs [d]				*P*<.001	*P*<.001
≥2	869 (9.9)	108	12.4	1.73 (1.38–2.17)	1.70 (1.35–2.15)
1	2560 (29.3)	249	9.7	1.30 (1.10–1.54)	1.27 (1.07–1.50)
None	5308 (60.8)	402	7.6	Reference	Reference
Primary Diagnosis [e]				*P*=.004	*P*=.01
Depression	4703 (53.8)	384	8.2	Reference	Reference
Bipolar disorders	828 (9.5)	72	8.7	1.08 (0.83–1.42)	1.04 (0.79–1.36)
Externalizing disorders	788 (9.0)	75	9.5	1.15 (0.88–1.50)	1.06 (0.81–1.38)
Reaction disorders	394 (4.6)	25	6.3	0.77 (0.51–1.18)	0.76 (0.50–1.17)
Psychosis	605 (6.9)	74	12.2	1.54 (1.18–2.01)	1.50 (1.14–1.96)
Anxiety disorders	344 (3.9)	38	11	1.36 (0.95–1.94)	1.29 (0.90–1.84)
Attention-deficit/hyperactivity disorder	554 (6.3)	56	10.1	1.21 (0.89–1.64)	1.06 (0.77–1.46)
Autism spectrum disorder	138 (1.6)	17	12.3	1.59 (0.94–2.69)	1.56 (0.92–2.63)
Eating disorders	149 (1.7)	10	6.7	0.82 (0.42–1.58)	0.79 (0.41–1.54)
Substance-related disorders	69 (0.8)	1	1.4	0.17 (0.02–1.19)	0.19 (0.03–1.40)
Other MH diagnoses	165 (1.9)	7	4.2	0.49 (0.23–1.06)	0.48 (0.22–1.05)
Race/Ethnicity				*P*<.001	*P*=.01
Hispanic	1410 (16.1)	143	10.1	1.50 (1.19–1.87)	1.38 (1.10–1.74)
Non-Hispanic Black	2170 (24.8)	229	10.6	1.56 (1.28–1.90)	1.40 (1.14–1.72)
Asian or Pacific Islander	213 (2.4)	14	6.6	0.93 (0.53–1.64)	0.96 (0.55–1.68)
Other	1290 (14.8)	121	9.4	1.36 (1.07–1.73)	1.26 (0.99–1.60)
Non-Hispanic White	3654 (41.8)	252	6.9	Reference	Reference
Insurance				*P*=.01	*P*=.50
Public	5180 (59.3)	499	9.6	1.31 (1.10–1.55)	1.11 (0.93–1.33)
None	216 (2.5)	17	7.9	1.06 (0.63–1.78)	1.00 (0.60–1.69)
Other	93 (1.1)	5	5.4	0.71 (0.29–1.78)	0.69 (0.28–1.73)
Private	3248 (37.2)	238	7.3	Reference	Reference

[a] Mental health was the primary diagnosis of 8,737 (16.8%) of 51,922 index admissions at hospitals in the 2014 AHRQ/HCUP New York State Inpatient Database.

[b] To assess whether readmission rates varied by each patient characteristic, *P* value from multiple degrees of freedom block test on all categories of each characteristic was calculated from a hierarchical logistic regression model with fixed effect for the characteristic and random effect for hospital.

[c] Adjusted odds ratio from hierarchical logistic regression model with random effect for hospital and fixed effects for all characteristics that were significant in bivariate analysis with $P<.20$.

[d] The Chronic Condition Indicators (CCIs), developed by the Agency for Healthcare Research and Quality, categorize approximately 14,000 ICD-9-CM diagnosis codes as chronic or not chronic and assign codes into one of 18 mutually exclusive body system groups.

[e] Other MH diagnoses include personality, reactive attachment, motor, elimination, developmental, and sexual/gender identity disorders, each accounting for <1% of MH admissions.

APPENDIX B. CALCULATION OF CASE-MIX-ADJUSTED HOSPITAL READMISSION RATES

This section describes how case-mix-adjusted readmission rates were calculated for hospitals. We first detail how readmission rates are modeled using a multilevel logistic regression model. We next describe how model estimates are transformed to obtain adjusted rates and errors for each hospital.

B.1. Multilevel Logistic Model for Readmission Rate

Let $Y_{ij} = 1$ be an indicator of readmission following the jth index admission in the ith hospital and $\mathbf{X}'_{ij} = (1, X_{ij1}, ..., X_{ijk})$ is a vector of k case-mix covariates,.

We defined a mixed logistic regression model with the form

$$\Pr(Y_{ij} = 1) = p_{ij}$$

$$\text{logit}(\mathbf{p}) = \mathbf{X}\boldsymbol{\beta} + \mathbf{U}\boldsymbol{\delta}$$

$$\delta_1, ..., \delta_m \overset{\text{iid}}{\sim} \text{N}(0, \sigma^2),$$

where $Y_{ij}|p_{ij}$ are mutually independent, $\boldsymbol{\delta}' = (\delta_1, ..., \delta_m)$, $\mathbf{X} = (\mathbf{X}'_{11}...\mathbf{X}'_{1n_1}...\mathbf{X}'_{mn_m})$, and $\mathbf{U}$ is a $\sum_{i=1}^{m} n_i \times m$ matrix with each row in the n_ith block having a 1 in the ith column and 0 otherwise.

The expected value at hospital i with its patient case-mix $\mathbf{X}_i$ was estimated as

$$\hat{E}_{s_i}(\mathbf{X}_i) = \sum_{j=1}^{n_i} \hat{p}_{ij}$$

$$\hat{p}_{ij} = \frac{1}{1 + e^{-(\mathbf{X}'_{ij}\hat{\boldsymbol{\beta}} + \hat{\delta}_i)}},$$

where $\hat{\boldsymbol{\beta}}$ is the maximum likelihood estimate of $\boldsymbol{\beta}$ and $\hat{\delta}_i$ is the best linear unbiased predictor, an empirical Bayes estimator obtained from `PROC GLIMMIX`.

B.1. Adjusted Rate Calculation

In order to obtain predictions on an untransformed scale, we introduced a retransformation bias correction factor, given unbiased and consistent quantities in the logit scale do not necessary retransform into unbiased or consistent quantities on the original scale. Our approach here is analogous to the *smearing estimate*, a nonparametric approach proposed by Duan (1983).

We approximated the expected value for hospital i under the distribution of the "average case-mix." The risk-adjusted readmission rate (RARR) of hospital i,

$$RARR_i = \left(\frac{\hat{E}_{s_i(\mathbf{X})}}{N}\right) \text{(Bias correction factor)}$$

$$\text{Bias correction factor} = \frac{\sum_{i=1}^{m}\sum_{j=1}^{n_i} y_{ij}^{\text{obs}}}{\sum_{i=1}^{m} \hat{E}_{s_i(\mathbf{X}_i)}}$$

Standard error of prediction from **PROC GLIMMIX** is then used to construct the confidence interval,

$$\frac{1}{N} \cdot \left[LCL(\hat{E}_{s_i(\mathbf{X})}), UCL(\hat{E}_{s_i(\mathbf{X})})\right] \cdot \left[\frac{\sum_{i=1}^{m}\sum_{j=1}^{n_i} y_{ij}^{\text{obs}}}{\sum_{i=1}^{m} \hat{E}_{s_i(\mathbf{X}_i)}}\right],$$

where N is the total number of index admissions in the cohort.

Duan N. Smearing Estimate: A Nonparametric Retransformation Method. J Am Stat Assoc. 1983;78(383):605. doi: 10.1080/01621459.1983.10478017.