# Factors Related to Pediatric Readmissions of Four Major Diagnostic Categories in Hawai‘i

Breanna Morrison PhD; Eunjung Lim PhD; Hyeong Jun Ahn PhD; John J. Chen PhD

## Abstract

*Readmissions are a key quality measure for health care decision making and understanding variables associated with readmissions has become a crucial research area. This study identified patient-level factors that might be associated with pediatric readmissions using a database that included inpatient data from 2008 to 2017 from Hawai‘i. Four major diagnostic categories with the most pediatric readmissions in the state were identified: respiratory, digestive, mental, and nervous system diseases and disorders. The associations between readmission and patient-level variables, such as age, sex, race/ethnicity, insurance status, and Charlson Comorbidity Index (CCI), were determined for each diagnosis and for overall readmissions. CCI and insurance were the strongest predictors when all diagnoses were combined. However, for some diagnoses, there was weak or no association between CCI, insurance, and readmission. This suggests that diagnosis-specific analysis of predictors of readmission may be more useful than looking at predictors of readmission for all diagnoses combined. While this study focused on patient variables, future studies should also incorporate how hospital variables may also be related to diagnosis.*

## Keywords

*Patient Readmission, Pediatrics, Hawai‘i, Comorbidities, Health Disparities*

## Abbreviations

*AUC = Area under the Curve*
*CCI = Charlson Comorbidity Index*
*CI = Confidence Interval*
*MDC = Major Diagnostic Category*
*NHPI = Native Hawaiian and Other Pacific Islander*
*OR = Odds Ratio*
*PPR = Potential Preventable Readmission*

## Introduction

Around 6.5% of hospitalized children have experienced a hospital readmission.[1] Re-hospitalized children often require a disproportionate amount of medical services and resources, resulting in higher medical costs and multiple hospitalizations.[2,3] Increased number of hospital visits can also negatively affect children's lives by increasing school absences,[4] development of posttraumatic stress response,[5] and family conflict.[6] In addition, multiple hospital visits across different hospitals can lead to a disconnect of patient health information, thereby increasing the risk of medical errors.[7]

While the overall readmission rate for pediatric patients is low, readmission rates vary by diagnosis. One multi-hospital study found that the most common reasons for pediatric admission were mood disorders, asthma, pneumonia, bronchitis, and epilepsy.[8] Type of diagnosis was strongly related to readmission risk. For example, 21.1% of children with neoplasm-related conditions such as leukemia or brain cancer, experienced an unplanned readmission within 30 days, compared to 9% of those with a mental disorder diagnosis and 6% of those with a respiratory-related diagnosis.[1]

Patient level variables also relate to readmission. Underserved populations, such as minorities and those with lower social economic status, have a higher risk of readmission even when controlling for diagnosis.[1,3,9–15] Studies have found that adult Native Hawaiian patients have higher rates of readmissions when compared with White patients.[16–18] However, there has been limited research looking at these variables among pediatric patients and their relationship to readmission in Hawai‘i. Some variables related to readmission are not tied to the patient, but to the environment instead. Variables such as day of visit, weather patterns, family composition, and peer relationships may correlate to readmissions for some diagnoses.[19–23]

Even with many variables identified, prediction of patient readmission has not been very successful.[24] It is even more challenging for pediatric readmissions as they have not been as well studied as readmissions for adults.[1] To fill this gap, this study focused on (1) identifying major diagnostic categories prevalent in the pediatric in-patient population in Hawai‘i and (2) exploring patient-level variables related to readmissions within each of those major diagnostic categories.

## Methods

### Sample

This was an observational retrospective study using statewide in-patient pediatric data for nearly all hospitals in Hawai‘i for the years 2008 to 2017.[25] The University of Hawai‘i Institutional Review Board deemed this study exempt from review. The dataset had detailed discharge information including unique patient identification (ID) numbers that allowed the tracking of patients within and across hospitals, Major Diagnostic Categories (MDCs) for each visit, and a potentially preventable readmission (PPR) chain indicator. A readmission chain was determined as a sequence of PPRs that were "clinically related to the initial admission," based on the 3M software, version 20 (3M Health Systems Information, Maplewood, MN). A readmission was considered potentially preventable if it could

have possibly been prevented with better quality of care at hospitalization, better discharge planning or follow-up, or better coordination between out and in-patient health care providers.[26] As a readmission chain is tied to its initial admission, readmissions might have different diagnoses from the initial admission diagnosis but initial admission MDC was used for classification of readmission. MDCs were classified using ICD-9 and ICD-10 codes depending on the year.

There were a total of 230 021 in-patient visits for patients under the age of 18 years. Excluded were newborn related visits (171 273 records), transfers (8506 records), visits with Department of Defense insurance (26 046 records), visits that included a non-Hawai'i resident (4237 records), and those who were marked as deceased during the first visit (832 records). Patients with Department of Defense insurance were excluded due to incomplete patient demographics. Additionally, if the initial visit in a readmission chain was excluded according to criteria above, the complete chain of visits was also removed (226 records). The final dataset contained 41 918 visits among 29 694 unique patients (Figure 1).

**Patient-level Variables**

Patient-level variables available were age, sex, race/ethnicity, patient geographic location, type of insurance, and Charlson Comorbidity Index (CCI).[27] After exploring the distribution of race/ethnicity, the race/ethnicity variable was categorized into 5 groups - White, Filipino, Native Hawaiian/Pacific Islander (NHPI), Asian but not Filipino, and other/unknown. Race/ethnicity was self-reported and patients chose the race/ethnicity they most closely identified with. Type of insurance was categorized as public (Medicare or Medicaid) versus all other payment types, which included mostly private insurance but also some self-pay and miscellaneous. Among the 4 MDCs in the "all other payment types" category, 94% had private insurance. Patient residence was classified as O'ahu island versus all other Hawaiian islands. CCI was categorized as 0 vs ≥ 1 to compare people with comorbidities to people with no additional conditions.

**Statistical Analysis**

First, the number of patients with a readmission by MDCs was determined. The top 4 MDCs with the most unique patient readmissions were identified for further investigation of the association between patient-level variables and readmission. If patients had multiple admissions for an MDC, 1 visit (initial visit if admission was part of a readmission chain) was randomly selected when assigning demographic variables to the patient. A multivariable logistic regression model was developed using R Statistics, 4.0.2 (R Core Team, Vienna, Austria) with the patient-level variables for all MDCs combined and for each of the 4 top MDCs. Odds ratios (ORs) and their 95% confidence intervals (CIs) were used to estimate the strength of the association between a patient-level variable and readmission. The area under the receiver operating characteristic curve (AUC) was calculated to evaluate the accuracy of the models. Statistical significance was set at $P < .05$.

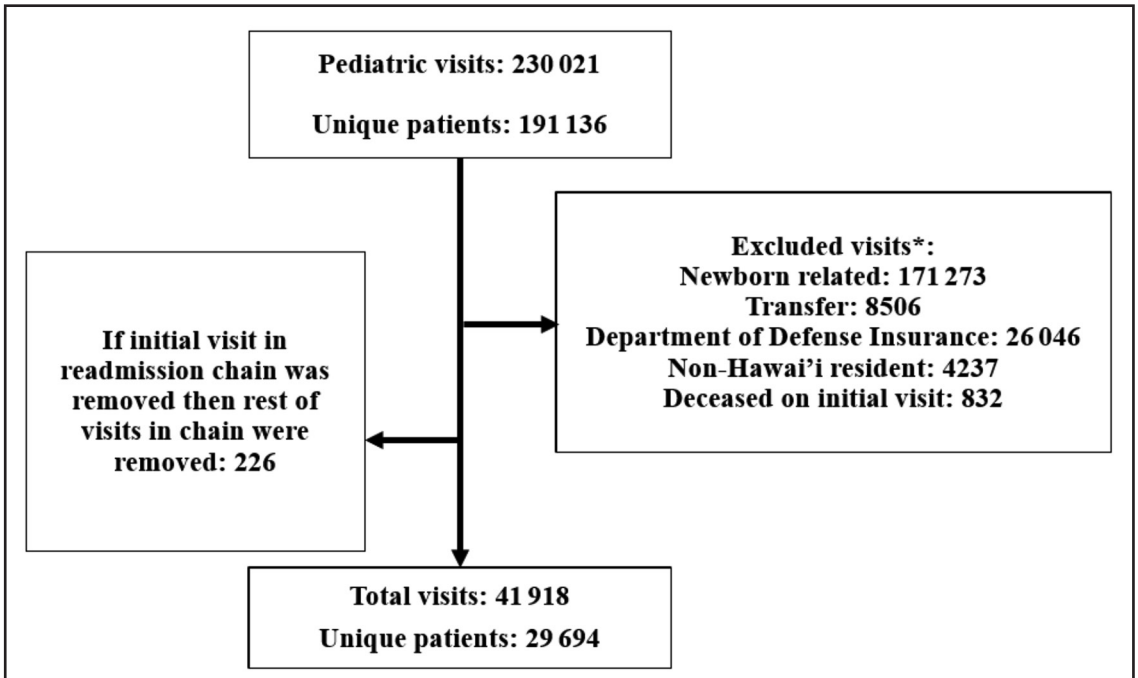


Figure 1. Pediatric Readmission Study Inclusion Flowchart, Hawai'i 2008-2017

## Results

Pediatric inpatient data, including readmissions, were summarized for MDCs (Table 1). The 4 diagnosis categories with the largest number of patients who had a readmission, each with at least 100 patients readmitted, were: diseases and disorders of the respiratory system (279 readmissions, percent who had a readmission = 4.1%), digestive system (171 readmissions, 4.4%), mental diseases and disorders (153 readmissions, 9.1%), and nervous system (118 readmissions, 4.5%).

A multivariable logistic model was created for all pediatric patients, regardless of diagnosis (Table 2). When looking at pediatric patients overall, the average age was 7.3 years and 51% were male. For race/ethnicity, 45% of pediatric patients were NHPI, 16% were Filipino and 15% were White. Fifty-eight percent were on public insurance and 14% had at least 1 comorbidity on initial admission. Sex, race/ethnicity, location, insurance, and CCI were all significant predictors of readmission. Male pediatric patients were more likely to have a readmission (odds ratio [OR] = 1.18, 95% confidence interval [CI] = 1.04 – 1.33). Patients who were NHPI (OR = 0.79, 95% CI = 0.66-0.94), Filipino (OR = 0.75, 95% CI = 0.61-0.94), or had other/missing as their race/ethnicity (OR = 0.77, 95% CI = 0.61-0.97) were all less likely to be readmitted. The strongest predictors of readmission however were residence (OR = 1.49, 95% CI = 1.29 - 1.71), insurance (OR = 1.34, 95% CI = 1.18 - 1.53), and CCI (OR = 1.86, 95% CI = 1.61 - 2.14) with patients on O‘ahu, those with public health insurance, and those with 1 or more comorbidities more likely to have a readmission. However, while many predictors were statistically significant, the AUC of the multivariable logistic regression model was only 0.593 and an acceptable AUC should be 0.7 or more.

The top 4 MDCs with the most pediatric readmissions were then evaluated to determine how variables might differ in their association with readmission from each other and from the overall model. The multivariable logistic regression model for predicting readmissions from respiratory system diseases and disorders had an AUC of 0.636 (Table 3). Insurance type, CCI, and patient’s residence were significant predictors of readmission. Patients on public insurance were about twice as likely to have a readmission as those not on public insurance (OR = 1.94, 95% CI = 1.44 - 2.63). Those having at least 1 comorbidity had 1.95 times higher odds of readmission as those without any comorbidities (OR = 1.95, 95% CI = 1.50 - 2.53). Those living on O‘ahu had 1.61 times higher odds of readmission as those living on the other islands (OR = 1.61, 95% CI = 1.21 - 2.15).

The AUC of the model for predicting readmissions for digestive diseases and disorders was 0.573. The only significant predictor for readmission for this MDC was CCI, with those having at least 1 comorbidity 1.79 times higher odds as likely to have a readmission (OR = 1.79, 95% CI = 1.23 - 2.62).

The model for predicting readmissions for patients diagnosed with mental diseases and disorders had an AUC of 0.591. The strongest predictor of readmission for this model was insurance type with those having public insurance more likely to have a readmission (OR = 1.46, 95% CI = 1.03 - 2.06). NHPI patients were less likely to have a readmission compared to white patients (OR = 0.58, 95% CI = 0.37 - 0.89).

Table 1. Number of Patients and Readmission Rate by Major Diagnostic Category

| Major Diagnostic Category | # Patients | # Readmissions | % Readmissions | Rank of Readmission % |
|---|---|---|---|---|
| Respiratory System | 6732 | 279 | 4.1 | 7 |
| Digestive System | 3905 | 171 | 4.4 | 6 |
| Mental Diseases & Disorders | 1691 | 153 | 9.0 | 1 |
| Nervous System | 2620 | 118 | 4.5 | 5 |
| Musculoskeletal System & Connective Tissue | 2748 | 84 | 3.1 | 11 |
| Endocrine, Nutritional & Metabolic | 1379 | 65 | 4.7 | 4 |
| Ear, Nose, Mouth & Throat | 2079 | 54 | 2.6 | 12 |
| Infectious & Parasitic Diseases | 1449 | 49 | 3.4 | 10 |
| Kidney & Urinary Tract | 1208 | 44 | 3.6 | 8 |
| Circulatory System | 694 | 42 | 6.1 | 3 |
| Skin, Subcutaneous Tissue & Breast | 2556 | 42 | 1.6 | 14 |
| Blood, Blood Forming Organs, Immunology | 887 | 31 | 3.5 | 9 |
| Hepatobiliary System & Pancreas | 308 | 26 | 8.4 | 2 |
| Injuries, Poisonings & Toxic Effects of Drugs | 817 | 16 | 2.0 | 13 |

Note: Initial visit was used to assign patient to major diagnosis categories (MDCs). Patients can be duplicated in the above chart if they had initial visits for multiple diagnoses. Rank of readmission shows the diagnoses category that had the highest percent of readmission (1) to lowest (14) excluding MDCs with 10 or less readmissions. Pregnancy related MDCs and MDCs with 0 patients were not included.

| Table 2. Association between Patient Characteristics and Readmission for All Causes | | | |
|---|---|---|---|
| **Variable** | **No Readmission, n = 28 555 (96.2%)** | **Readmission, n = 1139 (3.8%)** | **Odds Ratio (95% CI)** |
| **Age (years), Mean ± SD** | 7.26 ± 6.5 | 7.29 ± 6.5 | 1.00 (0.99 – 1.01) |
| **Sex** | | | |
| Female | 14 014 (96.5%) | 509 (3.5%) | Ref |
| Male | 14 541 (95.8%) | 630 (4.2%) | 1.18 (1.04 – 1.33)** |
| **Race/Ethnicity** | | | |
| White | 4292 (95.9%) | 184 (4.1%) | Ref |
| NHPI | 12 946 (96.2%) | 509 (3.8%) | 0.79 (0.66 – 0.94)** |
| Filipino | 4462 (96.5%) | 162 (3.5%) | 0.75 (0.61 – 0.94)* |
| Other Asian | 3256 (95.5%) | 154 (4.5%) | 1.01 (0.81 – 1.27) |
| Other/Missing | 3599 (96.5%) | 130 (3.5%) | 0.77 (0.61 – 0.97)* |
| **Patient's Residence** | | | |
| Rural (Other Islands) | 9527 (97.0%) | 291 (3.0%) | Ref |
| Urban (O'ahu) | 19 028 (95.7%) | 848 (4.3%) | 1.49 (1.29 – 1.71)*** |
| **Insurance** | | | |
| Other | 12 165 (96.6%) | 425 (3.4%) | Ref |
| Public (Medicaid/Medicare) | 16 390 (95.8%) | 714 (4.2%) | 1.34 (1.18 – 1.53)*** |
| **Charlson Comorbidity Index** | | | |
| 0 | 24 547 (96.6%) | 872 (3.4%) | Ref |
| ≥1 | 4008 (93.8%) | 267 (6.2%) | 1.86 (1.61 – 2.14)*** |

CI = Confidence Interval. SD = Standard Deviation. Ref = Reference. NHPI = Native Hawaiian and Pacific Islander. *$P$<.05, **$P$<.01; ***$P$<.001.
Multivariable logistic regression was conducted with the variables in the table. The AUC of the model was .593 (95% CI = 0.576 – 0.610).

| Table 3. Odds Ratios for Readmission by Patient Demographics by Major Diagnosis Category | | | | |
|---|---|---|---|---|
| **Variable** | **Respiratory System** | **Digestive System** | **Mental Health** | **Neurological** |
| **Age (years), Mean ± SD** | 1.01 (0.98 – 1.04) | 1.00 (0.97 – 1.03) | 0.96 (0.89 – 1.02) | 0.99 (0.95 – 1.02) |
| **Sex** | | | | |
| Female | Ref | Ref | Ref | Ref |
| Male | 1.17 (0.91 – 1.50) | 1.10 (0.80 – 1.50) | 1.08 (0.77 – 1.51) | 1.09 (0.74 – 1.60) |
| **Race/Ethnicity** | | | | |
| White | Ref | Ref | Ref | Ref |
| NHPI | 1.52 (0.93 – 2.48) | 0.86 (0.54 – 1.37) | 0.58 (0.37 - 0.89)* | 0.90 (0.50 – 1.62) |
| Filipino | 0.98 (0.55 – 1.75) | 1.18 (0.71 – 1.96) | 0.73 (0.44 – 1.22) | 0.96 (0.48 – 1.94) |
| Other Asian | 1.39 (0.75 – 2.60) | 1.16 (0.67 – 2.00) | 0.68 (0.40 – 1.16) | 1.26 (0.65 – 2.46) |
| Other/Missing | 1.26 (0.71 – 2.24) | 0.89 (0.50 – 1.60) | 0.91 (0.49 – 1.70) | 0.98 (0.46 – 2.08) |
| **Patient's Residence** | | | | |
| Rural (Other Islands) | Ref | Ref | Ref | Ref |
| Urban (O'ahu) | 1.61 (1.21 – 2.15)** | 1.16 (0.83 – 1.62) | 0.89 (0.61 – 1.31) | 1.94 (1.18 – 3.19)** |
| **Insurance** | | | | |
| Other | Ref | Ref | Ref | Ref |
| Public (Medicaid/Medicare) | 1.94 (1.44 – 2.63)*** | 0.91 (0.66 – 1.26) | 1.46 (1.03 – 2.06)* | 1.10 (0.74 – 1.65) |
| **Charlson Comorbidity Index** | | | | |
| 0 | Ref | Ref | Ref | Ref |
| ≥1 | 1.95 (1.50 – 2.53)*** | 1.79 (1.23 – 2.62)** | 0.94 (0.58 – 1.51) | 3.59 (2.40 – 5.38)*** |
| **Overall Model AUC** | 0.64 (0.60 – 0.67) | 0.57 (0.53 – 0.62) | 0.59 (0.54 – 0.64) | 0.66 (0.61 – 0.72) |

CI = Confidence Interval. SD = Standard Deviation. Ref = Reference. NHPI = Native Hawaiian and Pacific Islander.
*$P$<.05, **$P$<.01; ***$P$<.001.

The model for predicting readmissions for patients with neurological diseases and disorders had an AUC of 0.664. CCI and patient's residence were significant predictors of readmission. Those having at least one comorbidity had 3.59 greater odds of being readmitted than those with no comorbidity (OR = 3.59, 95% CI = 2.40 - 5.38). Those living on O'ahu had increased odds of readmission compared to those living on the other islands (OR = 1.94, 95% CI = 1.18 - 3.19).

## Discussion

Four Major Diagnostic Groups were evaluated to determine which variables were related to readmission for those diagnoses. Similar to the national pediatric readmissions rate of 6.5%,[1] there were relatively low pediatric readmission rates overall in Hawai'i (3.8%). The pediatric distribution in this study seems to have a higher proportion of NHPI patients and lower proportion of White patients compared with studies based on Hawai'i adult inpatients.[16] In contrast, the locations where pediatric and adult patients came from (particularly O'ahu versus other places) seem similar.[16] The variables that related most to overall readmission rate were residence, insurance type, and CCI. While some variables tended to be relatively consistent across the diagnostic categories in their relationship to readmission, this was not the case for all diagnostic categories and the readmission rates for diagnoses also varied.

The current study showed that patients on public insurance had a higher risk of readmission for the respiratory and mental health diagnosis categories, which is consistent with many studies involving insurance as a variable.[1,3,13,15,19,29] However, this relationship was not present in this study for the digestive or neurological diagnoses. Some studies that have looked specifically at certain neurological disorders[30] and digestive disorders[31] for adult patients found that those on public insurance had higher readmissions. However pediatric studies focused on certain neurological disorders[32] and digestive disorders[33] found that insurance was not a significant predictor of readmission when controlling for other patient variables which is more aligned with the findings from this study. These highlight potential differences in predictors of readmission between pediatric and adult patients and by diagnosis.

Additionally, patients with comorbidities had a higher risk of readmission in all MDCs studied except the mental diseases and disorders category. These findings are consistent with the current literature.[34–37] Patients on O'ahu had a higher risk of readmission than patients from other islands in Hawai'i. Even though not all patients on O'ahu would be considered to live in urban areas, they tend to have easier access to more advanced medical facilities; therefore, this island difference in readmission may possibly be an indicator of how rural and urban residence of patients may relate to PPRs. Others have also found that rural areas had lower readmission rates as well.[38] However, there have also been studies suggesting that certain diagnoses showed higher readmissions at rural hospitals[39] while others found no differences between rural and urban.[40] More studies are needed to better understand urban/rural hospital differences.

The rates of readmission for pediatric patients who are NHPI depended on diagnosis and the association tended to be weak. It is worth noting that this relationship tended to show NHPI patients having a lower risk of readmission which is in the opposite direction of what other studies on NHPI readmission have found.[16–18] However, those were all done with the adult population. More research should be conducted to evaluate whether and how readmission rates for NHPI may vary across age.

Hospital readmissions have been of increasing interest to researchers, policy makers, and health officials. The Affordable Care Act established a Hospital Readmissions Reduction Program (HRRP) that would reduce payments made to hospitals if their readmission rates for certain diagnoses were above what would be expected but only for some groups of patients and for some diagnoses.[41] This approach assumes that the hospital would be the main catalyst in reducing readmissions, while the literature demonstrates that various patient level variables are also related to readmission. Additionally, readmission is not always a negative outcome as it could be seen as a preventative measure for an even worse outcome like death. While readmission rate is an important outcome, the use of readmission rate as a quality of care indicator has been criticized for various reasons ranging from data issues regarding readmission statistics to the oversimplification of viewing the medical care providers as the primary reason for readmission.[9,29,42,43] If hospitals were penalized for having higher readmission rates without accounting for patient demographics, resources could be denied to institutions taking care of higher risk patients.[44]

Other literature studying readmissions has indicated multiple variables that relate to readmission but overall, the prediction of readmission has been difficult with most AUCs below 0.70.[24,45] The AUC for the readmission models in the current study was usually around 0.60. With the difficulty in predicting readmissions in this and other similar studies,[24] more research incorporating additional variables, at both the patient and hospital levels, should be done in the future to increase our understanding of what relates to pediatric readmissions.

The study has several limitations. Due to the relatively small sample size of the pediatric readmissions and limited data available on pediatric patients and hospitals in Hawai'i, incorporating hospital levels variables into the model was not feasible with the current sample. Second, MDCs were used rather than more specific diagnosis groups which could have provided more details into readmissions relating to diagnosis. This can affect the estimated strengths of the associations of the variables as MDCs could encompass a broad number of diagnoses which may have different rates of readmission or different strengths of associations related to readmission. Third,

the data lack details about dates of admissions and discharges due to confidentiality. This study used readmission based on the 3M PPR definition already built in the dataset. This could have led to some discrepancies with other investigations that were able to consider all readmissions based on detailed admission and discharge dates. Fourth, with the context of secondary data analysis, the quality and selection of variables of the current data could be limited. Additionally, readmission was the only outcome looked at. Length of stay or death could have been related to readmission as well and have shown additional information concerning pediatric readmissions.

This study found that Hawai'i pediatric patients with public insurance and those with more comorbidities had a higher rate of hospital readmission overall. Although the model fits were not very strong in either the overall model or within diagnoses, the different strengths of variables for different diagnosis categories suggest the usefulness of analyzing readmissions by diagnosis. Additionally, due to the increasing use of hospital readmission rates in health care decision making, more studies should be done to better understand how diagnosis, patient, and hospital level variables interact to predict pediatric readmission.

## Conflict of Interest

None of the authors identify a conflict of interest.

## Funding/Support

This project was partially supported by U54MD007601 (Ola HAWAI'I) and U54GM104944 (MW CTR-IN) grants from the National Institutes of Health. The funding agency did not participate in this work.

Authors' Affiliation:
- Department of Quantitative Health Sciences, John A. Burns School of Medicine, University of Hawai'i, Honolulu, HI

Corrsponding Author:
Breanna Morrison PhD; Quantitative Health Sciences, John A. Burns School of Medicine, 651 Ilalo St., MEB, Suite 411, Honolulu, HI 96813;
Email: bmmorris@hawaii.edu

### References

1. Berry JG, Toomey SL, Zaslavsky AM, et al. Pediatric readmission prevalence and variability across hospitals. *J Am Med Assoc*. 2013;309(4):372. doi:10.1001/jama.2012.188351
2. Kelly A, Hewson P. Factors associated with recurrent hospitalization in chronically ill children and adolescents. *J Paediatr Child Health*. 2000;36(1):13-18. doi:10.1046/j.1440-1754.2000.00435.x
3. Berry JG. Hospital utilization and characteristics of patients experiencing recurrent readmissions within children's hospitals. *J Am Med Assoc*. 2011;305(7):682. doi:10.1001/jama.2011.122
4. Shaw SR, McCabe PC. Hospital-to-school transition for children with chronic illness: Meeting the new challenges of an evolving health care system. *Psychol Sch*. 2008;45(1):74-87. doi:10.1002/pits.20280
5. Rennick JE, Johnston CC, Dougherty G, Platt R, Ritchie JA. Children's psychological responses after critical illness and exposure to invasive technology: *J Dev Behav Pediatr*. 2002;23(3):133-144. doi:10.1097/00004703-200206000-00002
6. Chen E, Bloomberg GR, Fisher EB, Strunk RC. Predictors of repeat hospitalization in children with asthma: The role of psychosocial and socioenvironmental factors. *Health Psychol*. 2003;22(1):12-18. doi:10.1037/0278-6133.22.1.12
7. Bourgeois FC. Patients treated at multiple acute health care facilities: Quantifying information fragmentation. *Arch Intern Med*. 2010;170(22):1989. doi:10.1001/archinternmed.2010.439
8. HCUP. Most Common Diagnoses for Inpatient Stays. Agency for Healthcare Research and Quality. https://www.hcup-us.ahrq.gov/faststats/NationalDiagnosesServlet?year1=2015&characteristic1=0&included1=0&year2=2014&characteristic2=21&included2=0&expansionInfoState=hide&dataTablesState=hide&definitionsState=hide&exportState=hide Published 2014. Updated 2021. Accessed July 3, 2019.
9. Fischer C, Lingsma HF, Marang-van de Mheen PJ, Kringos DS, Klazinga NS, Steyerberg EW. Is the readmission rate a valid quality indicator? A review of the evidence. Wu W-CH, ed. *PLoS ONE*. 2014;9(11):e112282. doi:10.1371/journal.pone.0112282
10. Pollack HA, Wheeler JRC, Cowan A, Freed GL. The impact of managed care enrollment on emergency department use among children with special health care needs: *Med Care*. 2007;45(2):139-145. doi:10.1097/01.mlr.0000250257.26093.f0
11. Flores G, Abreu M, Chaisson CE, Sun D. Keeping children out of hospitals: Parents' and physicians' perspectives on how pediatric hospitalizations for ambulatory care-sensitive conditions can be avoided. *Pediatrics*. 2003;112(5):1021-1030. doi:10.1542/peds.112.5.1021
12. Neuman MI, Alpern ER, Hall M, et al. Characteristics of recurrent utilization in pediatric emergency departments. *Pediatrics*. 2014;134(4):e1025-e1031. doi:10.1542/peds.2014-1362
13. Chung HS, Hathaway DK, Lew DB. Risk factors associated with hospital readmission in pediatric asthma. *J Pediatr Nurs*. 2015;30(2):364-384. doi:10.1016/j.pedn.2014.09.005
14. Hunt KA, Weber EJ, Showstack JA, Colby DC, Callaham ML. Characteristics of frequent users of emergency departments. *Ann Emerg Med*. 2006;48(1):1-8. doi:10.1016/j.annemergmed.2005.12.030
15. Feudtner C, Levin JE, Srivastava R, et al. How well can hospital readmission be predicted in a cohort of hospitalized children? A retrospective, multicenter study. *Pediatrics*. 2009;123(1):286-293. doi:10.1542/peds.2007-3395
16. Sentell TL, Ahn HJ, Juarez DT, et al. Comparison of potentially preventable hospitalizations related to diabetes among Native Hawaiian, Chinese, Filipino, and Japanese elderly compared with Whites, Hawai'i, December 2006–December 2010. *Prev Chronic Dis*. 2013;10:120340. doi:10.5888/pcd10.120340
17. Sentell TL, Ahn HJ, Miyamura J, Juarez DT. Cost burden of potentially preventable hospitalizations for cardiovascular disease and diabetes for Asian Americans, Pacific Islanders, and Whites in Hawai'i. *J Health Care Poor Underserved*. 2015;26(2A):63-82. doi:10.1353/hpu.2015.0068
18. Sentell T, Ahn HJ, Miyamura J, Taira DA. Thirty-day inpatient readmissions for Asian American and Pacific Islander subgroups compared with Whites. *Med Care Res Rev*. 2018;75(1):100-126. doi:10.1177/1077558716676595
19. Akenroye AT, Thurm CW, Neuman MI, et al. Prevalence and predictors of return visits to pediatric emergency departments: Return visits to pediatric EDs. *J Hosp Med*. 2014;9(12):779-787. doi:10.1002/jhm.2273
20. Tolbert PE, Mulholland JA, MacIntosh DL, et al. Air quality and pediatric emergency room visits for asthma and Atlanta, Georgia, USA. *Am J Epidemiol*. 2000;151(8):798-810.
21. Hashimoto M, Fukuda T, Shimizu T, et al. Influence of climate factors on emergency visits for childhood asthma attack. *Pediatr Int*. 2004;46(1):48-52. doi:10.1111/j.1442-200X.2004.01835.x
22. Hudson SM, Newman SD, Hester WH, Magwood GS, Mueller M, Laken MA. Factors influencing hospital admissions and emergency department visits among children with complex chronic conditions: A qualitative study of parents' and providers' perspectives. *Issues Compr Pediatr Nurs*. 2014;37(1):61-80. doi:10.3109/01460862.2013.855844
23. Tossone K, Jefferis E, Bhatta MP, Bilge-Johnson S, Seifert P. Risk factors for rehospitalization and inpatient care among pediatric psychiatric intake response center patients. *Child Adolesc Psychiatry Ment Health*. 2014;8(1):27. doi:10.1186/1753-2000-8-27
24. Artetxe A, Beristain A, Graña M. Predictive models for hospital readmission risk: A systematic review of methods. *Comput Methods Programs Biomed*. 2018;164:49-64. doi:10.1016/j.cmpb.2018.06.006
25. Hawaii Health Information Corporation. HHIC Inpatient Data. Accessed August 19, 2019.
26. Goldfield NI, McCullough EC, Hughes JS, et al. Identifying potentially preventable readmissions. *Health Care Financ Rev*. 2008;30(1):75-91.
27. Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: Development and validation. *J Chronic Dis*. 1987;40(5):373-383. doi:10.1016/0021-9681(87)90171-8
28. *R Statistics* Version 4.0.2 (R Core Team: Vienna, Austria)
29. Bardach NS, Vittinghoff E, Asteria-Penaloza R, et al. Measuring hospital quality using pediatric readmission and revisit rates. *Pediatrics*. 2013;132(3):429-436. doi:10.1542/peds.2012-3527
30. Guterman EL, Douglas VC, Shah MP, Parsons T, Barba J, Josephson SA. National characteristics and predictors of neurologic 30-day readmissions. *Neurology*. 2016;86(7):669-675. doi:10.1212/WNL.0000000000002379
31. Mudireddy P, Scott F, Feathers A, Lichtenstein GR. Inflammatory bowel disease: Predictors and causes of early and late hospital readmissions. *Inflamm Bowel Dis*. 2017;23(10):1832-1839. doi:10.1097/MIB.0000000000001242
32. Hong A, Shah Y, Singh K, Karkare S, Kothare S. Characteristics and predictors of 7- and 30-day hospital readmissions to pediatric neurology. *Neurology*. 2019;92(16):e1926-e1932. doi:10.1212/WNL.0000000000007280
33. Barnes EL, Kochar B, Long MD, et al. The burden of hospital readmissions among pediatric patients with inflammatory bowel disease. *J Pediatr*. 2017;191:184-189.e1. doi:10.1016/j.jpeds.2017.08.042
34. Logue E, Smucker W, Regan C. Admission data predict high hospital readmission risk. *J Am Board Fam Med*. 2016;29(1):50-59. doi:10.3122/jabfm.2016.01.150127
35. Nakagawa K, Ahn HJ, Taira DA, Miyamura J, Sentell TL. Ethnic comparison of 30-day potentially preventable readmissions after stroke in Hawaii. *Stroke*. 2016;47(10):2611-2617. doi:10.1161/STROKEAHA.116.013669
36. Hasan O, Meltzer DO, Shaykevich SA, et al. Hospital readmission in general medicine patients: A prediction model. *J Gen Intern Med*. 2010;25(3):211-219. doi:10.1007/s11606-009-1196-1
37. Picker D, Heard K, Bailey TC, Martin NR, LaRossa GN, Kollef MH. The number of discharge medications predicts thirty-day hospital readmission: a cohort study. *Br Med J Health Serv Res*. 2015;15(1):282. doi:10.1186/s12913-015-0950-9
38. Herrin J, St. Andre J, Kenward K, Joshi MS, Audet A-MJ, Hines SC. Community factors and hospital readmission rates. *Health Serv Res*. 2015;50(1):20-39. doi:10.1111/1475-6773.12177
39. Dharmarajan K, Hsieh AF, Lin Z, et al. Hospital readmission performance and patterns of readmission: retrospective cohort study of Medicare admissions. *Br Med J*. 2013;347(nov19 23):f6571-f6571. doi:10.1136/bmj.f6571

40. Krumholz HM, Lin Z, Keenan PS, et al. Relationship between hospital readmission and mortality rates for patients hospitalized with acute myocardial infarction, heart failure, or pneumonia. *J Am Med Assoc*. 2013;309(6):587. doi:10.1001/jama.2013.333
41. Hospital Readmissions Reduction Program (HRRP). Published January 16, 2019. https://www.cms.gov/medicare/medicare-fee-for-service-payment/acuteinpatientpps/readmissions-reduction-program.html. Accessed July 3, 2019.
42. Axon RN, Williams MV. Hospital readmission as an accountability measure. *J Am Med Assoc*. 2011;305(5):504. doi:10.1001/jama.2011.72
43. Benbassat J, Taragin M. Hospital readmissions as a measure of quality of health care: Advantages and limitations. *Arch Intern Med*. 2000;160(8):1074. doi:10.1001/archinte.160.8.1074
44. Sills MR, Hall M, Colvin JD, et al. Association of social determinants with children's hospitals' preventable readmissions performance. *JAm Med Assoc Pediatr*. 2016;170(4):350. doi:10.1001/jamapediatrics.2015.4440
45. Fischer JE, Bachmann LM, Jaeschke R. A readers' guide to the interpretation of diagnostic test properties: clinical example of sepsis. *Intensive Care Med*. 2003;29(7):1043-1051. doi:10.1007/s00134-003-1761-8