BRIEF REPORT

# Prevalence and Trends in Obesity Among Hospitalized Children

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ABSTRACT

**OBJECTIVES:** As obesity rates rise in children, it is likely that the number of hospitalized children with obesity is also increasing. However, characterization of the inpatient population with obesity as a whole has not been reported. We aimed to examine trends in the annual prevalence of obesity in hospitalized children and to identify demographic and clinical characteristics associated with higher obesity prevalence in children who are hospitalized.

**METHODS:** We completed a retrospective cohort analysis of children aged 2 to 19 years admitted to a single tertiary children's hospital system for any reason in 2009–2016. Body mass index was calculated from documented height and weight. Children with obesity were defined by using age- and sex-specific body mass index percentile guidelines established by the Centers for Disease Control and Prevention. Annual obesity prevalence was calculated on the encounter level for service line and All Patients Refined Diagnosis-Related Groups (diagnosis groups). $\chi^2$ tests were used to determine statistical differences between groups, and the Cochran-Armitage test of trend was used to describe changes in obesity over time.

**RESULTS:** Of 83 329 children who were hospitalized, 17.0% had obesity, increasing from 16.5% of hospitalizations in 2009–2010 to 17.3% in 2015–2016 ($P = .002$). Service lines with the highest obesity prevalence included orthopedics (22.1%), infectious disease (20.6%), and neuroscience (18.7%). Diagnosis groups with the highest obesity prevalence included cellulitis (22.5%), tonsil/adenoid procedures (22.0%), and some orthopedic procedures (28.7%).

**CONCLUSIONS:** Some groups of children who were hospitalized experience higher obesity prevalence, including children hospitalized with orthopedic, infectious disease, and neurologic problems. In future research, investigators should target disproportionately affected groups by examining health outcomes, patient safety, and satisfaction issues.

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Childhood obesity rates continue to climb in the United States.[1] In addition to lifelong negative effects of obesity on individuals' health, obesity may also increase the risk of morbidity and adverse events during hospitalization.[2] Studies describing the effect of obesity for particular cohorts of pediatric inpatients (eg, patients with sepsis, procedure complications) are mixed, with some revealing that obesity may be associated with increased severity of illness and morbidity, longer length of stay, and higher hospitalization costs,[3–8] whereas others reveal no association with poor outcomes for patients with respiratory illnesses, such as asthma.[9] Patients with obesity are also at risk for experiencing other hazards associated with hospitalization, including lack of appropriate accommodations and equipment, and weight bias, which may affect patient care and satisfaction.[10–13] In consideration of these possible care inequities, obesity should be considered an important comorbidity during any hospitalization.

Although the number of hospitalized children with obesity is likely increasing,[14] a broad characterization of obesity in the inpatient population has proven difficult because of undercoding of obesity diagnoses by providers, leading to a vastly underestimated prevalence.[15,16] Currently available information regarding inpatient obesity prevalence reveals that ∼16% to 20% of children who are hospitalized have obesity.[4,17–19] However, these studies were limited in their description of this population, describing children with a single diagnosis and having a limited description of trends over time or through use of administrative databases that do not include patient-level information needed to calculate accurate BMIs.

More information regarding the trends of obesity and clinical characteristics of hospitalized children with obesity will add to the current literature by identifying groups of hospitalized patients most likely to have obesity, providing clear targets for future health outcomes research. This information may also aid health care systems in preparation and creation of interventions to improve the safety and equity of care and accommodations.[13] Therefore, our objectives were to (1) examine trends in the annual prevalence of obesity in children who are hospitalized and (2) identify clinical characteristics associated with obesity in children who are hospitalized.

## METHODS

### Study Design

This study was a retrospective cohort analysis of children admitted to a single tertiary children's hospital system between January 1, 2009, and December 31, 2016. Data were extracted from the hospital's electronic health record (Cerner Corporation; Kansas City, MO). This study was deemed non–human subjects research and was approved by the Children's Mercy Kansas City Institutional Review Board.

### Study Population and Measures

We included all inpatient encounters for children aged 2 to 19 years old hospitalized during the study period, mirroring the age groups reported by the NHANES obesity reports.[1,20] Directly measured weight and height measurements collected from the electronic health record were used to calculate BMI. If height was not recorded for a hospitalization encounter, it was imputed as the mean from other encounters during the same calendar year, if available. Encounters for a patient in a given year were excluded if complete anthropometric data were not obtainable from that calendar year. Outliers for BMI were removed by using the Centers for Disease Control and Prevention (CDC) SAS version 9.4 (SAS Institute Inc, Cary, NC) code for determination of biologically implausible values.[20] We excluded the annual encounters for 18 802 children (20 256 patient-years) because of incomplete or biologically implausible anthropometric data (Supplemental Fig 2). When comparing demographic characteristics of the excluded encounters with those of the included encounters, statistically significant, but not clinically meaningful, differences existed (eg, 52% of the included cohort were boys, compared with 53.6% of the excluded cohort) (Supplemental Table 3). De-identified individual participant data will not be made available.

The primary outcome was the annual prevalence of hospitalized children with obesity. We defined obesity according to the current CDC classification system for children of age- and sex-specific BMI percentiles of ≥95%, with CDC subclassifications of class I to class III obesity (class I obesity: ≥95th percentile; class II obesity: ≥120% of the 95th percentile, or BMI ≥ 35; and class III obesity: ≥140% of the 95th percentile, or BMI ≥ 40).[20,21]

We also assessed obesity prevalence by demographic and clinical characteristics, including hospital service line and diagnosis groups. Diagnosis groups were assigned by using the All Patients Refined Diagnosis-Related Groups (3M Corporation, Maplewood, MN) software and grouped into the following service lines: cancer care or hematology, cardiac care, respiratory, orthopedics, transplants, digestive disease, neuroscience, infectious disease, other medicine, and other surgery. We assessed obesity prevalence among the 3 diagnoses groups with the largest absolute number of patients within each service line.

### Statistical Analysis

All variables were summarized with frequencies and percentages, then compared across groups (with obesity versus without obesity) by using $\chi^2$ tests. Obesity prevalence was calculated in 2-year increments (similar to NHANES) and was compared across time by using Cochrane-Armitage trend tests. Obesity prevalence and comparisons across time were calculated overall, by service line, and by diagnosis group. All analyses were completed on the encounter level. All statistical analyses were performed by using SAS version 9.4 (SAS Institute, Inc), and $P < .05$ was considered statistically significant.

## RESULTS

### Overall Cohort Description and Hospital-Wide Obesity Trends

Approximately 1 in 6 (17%) of the 83 329 included hospitalizations were for children with obesity. Prevalence of obesity

was highest among children who were 12 to 15 years old (20.2%), among non-Hispanic black (18.9%) or Hispanic (23.9%) children, and among children with public insurance (19.8%; all $P < .001$) (Table 1). There were no statistically significant differences in obesity prevalence by sex ($P = .738$).

The proportion of hospitalized children with obesity increased over the study period from 16.5% of hospitalizations in 2009–2010 to 17.3% in 2015–2016 ($P = .002$) (Fig 1). Proportions of children with class I obesity ranged from 10.3% to 10.7%, not changing significantly over the study period ($P = -.273$). The prevalence of class II obesity ranged from 3.1% to 3.8%, increasing significantly over the study period ($P < .0001$). The prevalence of class III obesity ranged from 2.6% to 3.7% but did not reveal a statistically significant change over the study period ($P = .504$).

**TABLE 1** Demographics

| | Overall | Without Obesity | With Obesity | *P* |
|---|---|---|---|---|
| *N* (%) | 83 329 | 69 192 (83.0) | 14 137 (17.0) | |
| Age, y, *n* (%) | | | | <.001 |
| 2–5 | 27 675 (33.2) | 23 931 (34.6) | 3744 (26.5) | |
| 6–8 | 13 826 (16.6) | 11 600 (16.8) | 2226 (15.7) | |
| 9–11 | 12 247 (14.7) | 9962 (14.4) | 2285 (16.2) | |
| 12–15 | 18 275 (21.9) | 14 581 (21.1) | 3694 (26.1) | |
| 16–19 | 11 306 (13.6) | 9118 (13.2) | 2188 (15.5) | |
| Sex, *n* (%) | | | | .738 |
| Male | 43 329 (52) | 35 960 (52) | 7369 (52.1) | |
| Female | 40 000 (48) | 33 232 (48) | 6768 (47.9) | |
| Race, *n* (%) | | | | <.001 |
| Non-Hispanic white | 54 658 (65.6) | 46 254 (66.8) | 8404 (59.4) | |
| Non-Hispanic black | 13 682 (16.4) | 11 095 (16) | 2587 (18.3) | |
| Hispanic | 7319 (8.8) | 5567 (8) | 1752 (12.4) | |
| Asian American | 1155 (1.4) | 1039 (1.5) | 116 (0.8) | |
| Other | 6515 (7.8) | 5237 (7.6) | 1278 (9) | |
| Payer, *n* (%) | | | | <.001 |
| Government | 39 836 (47.8) | 31 935 (46.2) | 7901 (55.9) | |
| Private | 42 229 (50.7) | 36 247 (52.4) | 5982 (42.3) | |
| Other | 1264 (1.5) | 1010 (1.5) | 254 (1.8) | |

## Service Lines and Diagnosis Groups of Hospitalized Children With Obesity

The hospital service lines caring for the largest proportion of hospitalized children with obesity included orthopedics (22.1%), infectious disease (20.6%), and neuroscience (18.7%), with statistically significant differences existing between groups ($P < .001$; Table 2). The prevalence of obesity among children who were hospitalized increased between 2009 and 2016 for patients within only 2 service lines: digestive disease (13.9% in 2009–2010 to 15.8% in 2015–2016; $P = .012$), and other surgery (17.0% in 2009–2010 to 18.9% in 2015–2016; $P = .022$), with no statistically significant change in the other groups over time.

Several diagnosis groups within each service line (Table 2) had a disproportionate number of patients with obesity, including skin and soft tissue infections (22.5%), headaches (23.4%), poisonings (21.2%), tonsil and adenoid procedures (22.0%), and hip and lower leg orthopedic procedures (28.6 and 28.6%, respectively).

## DISCUSSION

In this study, we found that ~1 in 6 children aged 2 to 19 years who were hospitalized had obesity. We observed increases in the annual prevalence of obesity in the inpatient population, mirroring trends in the general US population.[1] Hospitalized patients with obesity were more likely to be adolescents, more likely to be African American and Hispanic, and more likely to have public insurance, characteristics that generally mirror recent NHANES data.[1] This indicates that hospitalized children with obesity are similar to children with obesity in the general population. Obesity prevalence and trends within the hospital population were also similar to estimated regional obesity rates.[22] Our study also included analyses of changes in obesity prevalence among demographic groups over time (2009–2016). The increases in obesity prevalence among

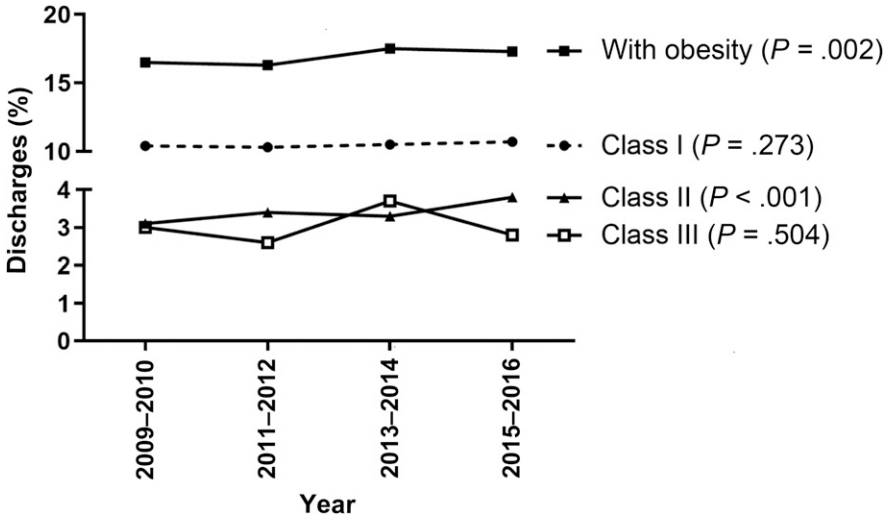


**FIGURE 1** Obesity prevalence over time.

**TABLE 2** Obesity Prevalence by Service Line and Most Common Diagnosis Groups

| Service Line[a] | Diagnosis Group | Overall Cases, *n* | Overall % With Obesity |
|---|---|---|---|
| Orthopedics | | 5840 | 22.1 |
| | Hip and femur procedures for nontrauma | 957 | 28.6 |
| | Dorsal and lumbar fusion procedures | 674 | 15.4 |
| | Knee and lower leg procedures, except foot | 637 | 28.7 |
| Infectious disease | | 5026 | 20.6 |
| | Cellulitis and skin and soft tissue infections | 1901 | 22.5 |
| | Viral illness | 711 | 16.2 |
| | Fever | 421 | 14.7 |
| Neuroscience service | | 7792 | 18.7 |
| | Seizure | 3037 | 18.0 |
| | Headaches | 906 | 23.4 |
| | Other disorders of nervous system | 738 | 24.3 |
| Other surgery | | 9094 | 18.1 |
| | Tonsil and adenoid procedures | 3946 | 22.0 |
| | Other ear, nose, mouth, and throat procedures | 645 | 15.7 |
| | Kidney and urinary tract procedures | 426 | 12.4 |
| Other medicine | | 14 798 | 17.5 |
| | Diabetes | 2474 | 15.6 |
| | Infections of upper respiratory tract | 1842 | 15.6 |
| | Poisoning of medicinal agents | 1340 | 21.2 |
| Cardiac care | | 3285 | 15.6 |
| | Percutaneous cardiovascular procedures | 388 | 13.7 |
| | Cardiac arrhythmia and conduction disorders | 356 | 15.2 |
| | Other cardiothoracic procedures | 355 | 9.6 |
| Respiratory | | 14 342 | 15.5 |
| | Asthma | 7365 | 17.7 |
| | Pneumonia | 2825 | 15.5 |
| | Bronchiolitis and RSV pneumonia | 1156 | 12.3 |
| Digestive disease | | 15 042 | 14.9 |
| | Appendectomy | 3105 | 17.4 |
| | Other digestive-system diagnoses | 2855 | 17.1 |
| | Nonbacterial gastroenteritis | 2620 | 11.3 |
| Transplants | | 330 | 14.5 |
| | Bone marrow transplant | 214 | 13.6 |
| | Kidney transplant | 91 | 16.5 |
| | Liver transplant and/or intestinal transplant | 20 | 15.0 |
| Cancer care or hematology | | 7766 | 14.0 |
| | Chemotherapy | 2961 | 14.9 |
| | Major hematologic or immunologic diagnosis, not sickle cell crisis and coagulopathy | 1372 | 12.0 |
| | Sickle cell anemia crisis | 1291 | 8.4 |

RSV, respiratory syncytial virus.
[a] $P < .001$ for the $\chi^2$ analysis between service line groups.

particular demographic groups noted within this hospitalized population were similar to those seen in the general population.[1] Our findings are in agreement with previous studies in which it was estimated that 16% to 21% of children who are hospitalized have overweight or obesity, making up a significant portion of the pediatric inpatient population.[15,17–19] Our study adds to those studies by providing a clearer description of the overall pediatric inpatient population over time through use of actual anthropometric measures, as opposed to children with particular diagnoses or through use of administrative data.

From a clinical perspective, 3 service lines cared for a larger proportion of patients with obesity (orthopedics, infectious disease, and neuroscience). We also found that only 2 of 10 service lines (digestive disease and other surgery) experienced statistically significant changes (increases) over the study period. These 2 groups were relatively large and were likely primary drivers of the overall increase in obesity prevalence for the entire cohort. However, smaller (but not statistically significant) increases noted in other service lines might, when taken in aggregate, have contributed to the overall increase in obesity prevalence noted in the children who were hospitalized.

In addition, we identified conditions with a disproportionate number of patients with obesity, including cellulitis, headaches, poisonings, tonsil and adenoid procedures, and orthopedic procedures. Many of the hospital outcomes for these conditions are negatively affected by weight status, including increased risk of postoperative complications (eg, orthopedic and tonsil procedures and adenoidectomy) and treatment failure (eg, cellulitis).[10,23–26] In addition, children with obesity require special attention to issues that affect their safety within the hospital setting.[10] For instance, children with obesity are at increased risk of experiencing medication dosing errors compared with children without obesity.[25,26] The knowledge gained from our findings may help providers and hospitals plan for and implement strategies aimed at improving care and safety for groups of children with higher obesity prevalence within the inpatient population.

As the number of hospitalized children with obesity continues to rise, especially within particular demographic and clinical groups, our findings reveal the need for further

research into the special risks that this population of patients faces. Future research should be aimed at identification of disparate outcomes and equity of experiences from the patient perspective for patients with obesity. Our findings provide a starting point for potential areas of focus within the pediatric inpatient population.

Regarding our study, some limitations should be considered. This was a single-center study at a tertiary children's hospital, limiting generalizability of our results. However, our data are generally reflective of the nationally representative NHANES data and regional population obesity prevalence. There were fewer patients in some groups, which may have introduced variability in the results (eg, minority groups). Additionally, it is possible that weight and height measurements included were not accurate or that All Patients Refined Diagnosis-Related Groups could have been misclassified on the basis of the billing or coding information provided. Finally, it is possible that there was some selection bias in the inclusion of patients; providers might have been more likely to obtain height measurements on patients with obesity, leading to an artificially inflated obesity prevalence.

## CONCLUSIONS

The prevalence of obesity among children who are hospitalized is rising. Additionally, there exist typologies of patients, service lines, and diagnosis groups with substantially higher than average obesity prevalence. These results reveal the need to focus future research efforts on these disproportionately affected groups, with studies aimed at identification of gaps in the safety and equity of clinical care for children with obesity.

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