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BRIEF REPORT

Pediatric Antimicrobial Stewardship Programs Reduce Antibiotic Use at Combined Adult-Pediatric Hospitals

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Implementation of dedicated pediatric antimicrobial stewardship programs (ASPs) at 2 combined adult-pediatric hospitals with existing ASPs was associated with sustained decreases in pediatric antibiotic use out of proportion to declines seen in adult inpatient units. ASPs in combined hospitals may not detect excessive pediatric antibiotic use without incorporating pediatric expertise.

Keywords. pediatric antimicrobial stewardship; antibiotic use in hospitalized children; antibiotic overuse.

Pediatric antimicrobial stewardship programs (ASPs) reduce inappropriate antimicrobial utilization, drug-related adverse events, antimicrobial resistance, and healthcare costs [1]. These data are derived primarily from freestanding children's hospitals, but <5% of United States hospitals are exclusively children's hospitals, and nearly 75% of pediatric discharges occur at hospitals other than freestanding children's hospitals [2, 3]. The Centers for Medicare and Medicaid Services and The Joint Commission require all acute care hospitals to implement multidisciplinary ASPs, document evidence-based antibiotic use (AU), and sustain improvement in AU across all hospital departments [4, 5]. However, neither organization explicitly requires hospitals that care for both children and adults to address pediatric AU.

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ASPs at freestanding children's hospitals differ fundamentally from those at other hospitals because all full-time equivalent (FTE) support is allocated to physicians and pharmacists with pediatric expertise and focus. Even at combined adult-pediatric hospitals with large pediatric populations, children account for a minority of patients, and ASPs are typically staffed by adult-medicine physicians and pharmacists. Whether ASPs at combined hospitals provide effective pediatric antimicrobial stewardship is not well-studied, and the impact of adding pediatric FTEs to these ASPs has not been assessed. To address this gap, we evaluated the impact of adding a pediatric ASP with dedicated effort and expertise for pediatric antimicrobial stewardship at 2 such hospitals.

METHODS

We conducted this observational study at 2 academic, quaternary medical centers that care for children and adults. University of Michigan Health (UMH) includes 750 adult and 250 pediatric beds and established a pediatric ASP in July 2015. Duke University Hospital (DUH) includes 800 adult and 200 pediatric beds and began a pediatric ASP in August 2017. Prior to implementing pediatric ASPs, both hospitals had well-established ASPs without pediatric physician or pharmacist FTEs. Both had policies and activities that included pediatric patients, such as prior authorization of restricted antimicrobials, surgical prophylaxis guidelines, limited pediatric guidelines (UMH), prospective audit and feedback and criteria restriction for select antibiotics (UMH), and automatic infectious diseases consults for *Staphylococcus aureus* bacteremia and candidemia (DUH). We defined pediatric ASP implementation as the hiring of a pediatric infectious diseases physician with dedicated FTE for pediatric antimicrobial stewardship. Thereafter, both hospitals gradually implemented and increased pediatric ASP initiatives, including additional pharmacy support 13–16 months after pediatric ASP initiation.

We studied trends in antibiotic use (AU) for 12 months before and 30 months after pediatric ASP implementation. AU was calculated monthly, stratified by pediatric and adult units, and reported as days of therapy per 1000 patient-days present (DOT) in 3 categories: all antibacterials (2023 National Healthcare Safety Network [NHSN] definition [6]), intravenous vancomycin (identified as a high-yield target by both institutions), and broad-spectrum antibacterials used for hospital-onset infections (BSHO; pediatric NHSN definition [6]). Observation units and labor and delivery/newborn units were excluded.

To assess for changes in pediatric AU over time, I-charts for pediatric DOT were generated using statistical process control methodology [7, 8]. For each chart, a baseline was calculated,

fixed, and extended using the first 20 data points, and the rules for common- versus special-cause variation were applied, with 2 exceptions. First, the UMH vancomycin baseline was calculated from 13 data points due to sustained special-cause variation detected at the pediatric ASP start date. Second, the DUH BSHO chart demonstrated nonsustained special-cause variation during the baseline period; these points were excluded from baseline analysis. When rules for special-cause variation were met, new limits were calculated, fixed, and extended using 12 data points.

Additionally, mean monthly DOT in the first and last years of observation was compared across pediatric and adult units using *t* tests. AU data from the Pediatric Health Information System database (PHIS) were also compared between UMH and other children's hospitals for patients <18 years of age. DUH does not submit data to PHIS and was excluded from this analysis.

Each institution's institutional review board classified this study as non–human subjects research. I-charts were generated with QI Macros (KnowWare International Inc, Denver, Colorado). DOTs were compared with Stata version 15 (StataCorp LLC, College Station, Texas).

RESULTS

Antibiotic use trends were similar at each institution (Figure 1). Prior to establishing pediatric ASPs, pediatric AU was equivalent to or lower than adult AU in all categories. Following pediatric ASP implementation, downward centerline shifts occurred in all AU categories at both institutions, denoting significant decreases in pediatric AU. All centerline shifts occurred approximately 1 year following pediatric ASP initiation, except for vancomycin at UMH, which decreased at pediatric ASP implementation, followed by a second decrease 20 months later.

Mean monthly AU decreased from first to final study year in all categories except UMH adult vancomycin. Pediatric antibacterial use declined by 15% at both institutions (UMH: 678 to 577 DOT, $P < .001$; DUH: 635 to 542 DOT, $P < .001$), while adult antibacterial use declined by 4% at UMH (709 to 680 DOT, $P = .002$) and 6% at DUH (725 to 683 DOT, $P < .0001$). Pediatric vancomycin use decreased by 32% at UMH (100 to 69 DOT, $P < .001$) and 25% at DUH (85 to 64 DOT, $P < .001$), while adult vancomycin use was unchanged at UMH (107 to 104 DOT, $P = .306$) and declined by 5% at DUH (132 to 125 DOT, $P = .012$). UMH BSHO use declined by 14% in both pediatric (196 to 168 DOT, $P = .002$) and adult (261 to 225 DOT, $P < .001$) units; DUH pediatric BSHO use decreased by 15% (153 to 131 DOT, $P = .005$) while adult BSHO use decreased by 9% (258 to 235 DOT, $P < .001$).

Across all antibiotic categories at both institutions, mean first-year adult AU was significantly higher than first-year pediatric AU, except for UMH vancomycin use, which was equivalent. Final-year adult AU was also significantly higher than final-year pediatric AU in all categories. Moreover, final-year adult AU was significantly higher than first-year pediatric AU in all categories at DUH and for BSHO at UMH; final-year adult vancomycin and all antibacterial use was equivalent to first-year pediatric use at UMH.

Using PHIS data, UMH AU in the first study year was 7.5% higher than peer AU for all antibacterials (661 vs 615 DOT), 44.7% higher for vancomycin (95 vs 65 DOT), and 33.3% higher for BSHO (180 vs 135 DOT). In the final study year, UMH AU was 3.3% below peer AU for all antibacterials (543 vs 562 DOT), 16.6% above for vancomycin (65 vs 56 DOT), and 16.8% above for BSHO (151 vs 129 DOT).

DISCUSSION

Implementation of dedicated pediatric ASPs at 2 combined adult-pediatric hospitals was associated with sustained decreases in pediatric AU out of proportion to contemporary declines in adult AU. Additionally, baseline pediatric AU was comparable to or lower than both baseline and final-year adult AU, despite benchmarking data indicating that baseline pediatric AU was substantially higher than AU at other children's hospitals. Taken together, this suggests that unnecessary pediatric AU may not be identified or prioritized in combined hospitals that lack pediatric ASPs. Furthermore, hospital-wide ASP initiatives and policies in these hospitals are unlikely to adequately address inappropriate pediatric AU, and even ASPs successful at improving adult AU may not fully optimize pediatric antimicrobial use.

Studies of pediatric ASP implementation in similar settings have demonstrated complimentary findings. In 2 combined hospitals, one with no prior ASP and one whose ASP excluded pediatric patients [9, 10], implementation of pediatric ASP activities improved pediatric AU, similar to findings in freestanding children's hospitals. In the study most comparable to ours, a pediatric ASP was implemented in a hospital with an existing ASP that provided some oversight of pediatric use, but no pediatric FTE was added [11]. While the ASP identified opportunities for improvement, pediatric AU trends were unchanged, in contrast to the impact observed in our hospitals.

These findings underscore the importance of dedicated pediatric effort and expertise for conducting effective pediatric antimicrobial stewardship, even in hospitals with well-established hospital-wide ASPs. Prior to establishing pediatric ASPs, UMH and DUH had reasonable allocations of physician and pharmacist FTE for the size of their respective combined hospitals [12], yet opportunities for optimizing pediatric AU remained. When dedicated pediatric physician effort was added, followed by gradual addition of dedicated pharmacist effort, both institutions decreased pediatric AU. Notably, the amount of added physician and pharmacist FTE was similar

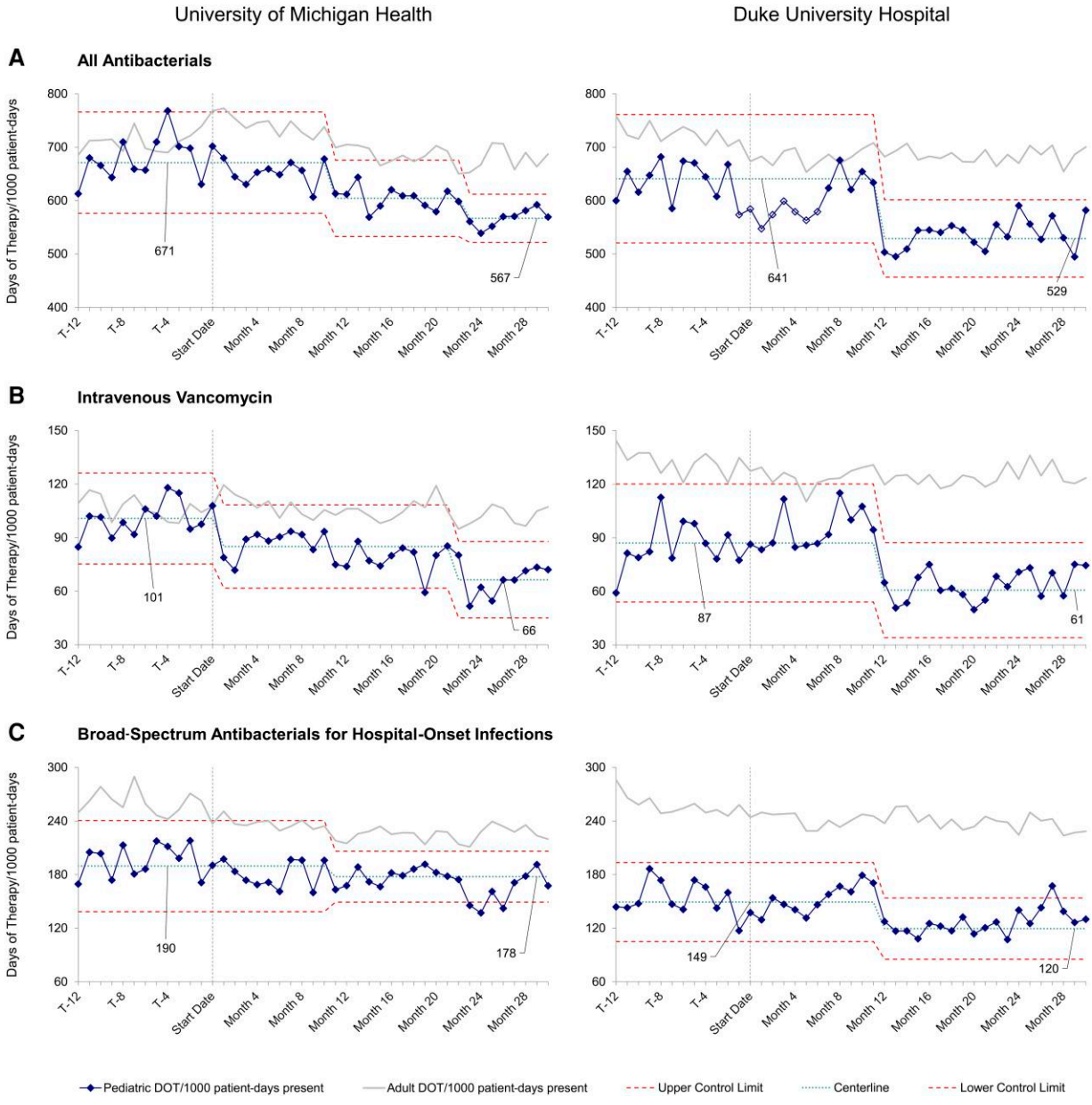

Figure 1. Antibiotic use trends at 2 combined adult-pediatric hospitals for 12 months before and 30 months after implementation of dedicated pediatric antimicrobial stewardship programs. Antibiotic use is reported as days of therapy (DOT) per 1000 patient-days present in 3 categories (2023 National Healthcare Safety Network [NHSN] definitions [6]): all antibacterials (*A*), intravenous vancomycin (*B*), and broad-spectrum antibacterials used for hospital-onset infections (*C*) (pediatric NHSN definition [6]). Data are displayed on I-charts with a dotted centerline and dashed lines denoting upper and lower control limits. Open data points in Duke University Hospital all antibacterial baseline data indicate nonsustained special cause; these points were excluded from baseline analysis.

to recommended FTE allocations for hospitals equivalent to UMH and DUH pediatric bed sizes [12]. Because pediatric ASP interventions and strategies varied across and within institutions, it is likely that pediatric expertise and the allocation of time to address the pediatric population and provider network facilitated the observed improvements, rather than any specific ASP activity.

Given these findings and observations, we strongly recommend that combined hospitals with pediatric inpatient populations dedicate ASP effort to physicians and pharmacists specifically tasked with stewarding pediatric AU. Adult and pediatric ASP effort should be tailored to the size of the adult and pediatric hospital components separately, rather than to the size of the entire hospital, because the patient populations, disease states encountered, and healthcare providers are substantially different between these entities. Furthermore, given that most pediatric discharges occur at combined hospitals, regulatory agencies should adopt pediatric-specific standards to

ensure that all hospitalized children receive appropriate antimicrobial stewardship. Without such effort and oversight, many hospitalized children will continue to receive unnecessary antibiotics.

Notes

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