Home Health Nursing Care and Hospital Use for Medically Complex Children

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abstract

BACKGROUND AND OBJECTIVE: Home health nursing care (HH) may be a valuable approach to long-term optimization of health for children, particularly those with medical complexity who are prone to frequent and lengthy hospitalizations. We sought to assess the relationship between HH services and hospital use in children.

METHODS: Retrospective, matched cohort study of 2783 hospitalized children receiving postdischarge HH services by BAYADA Home Health Care across 19 states and 7361 matched controls not discharged to HH services from the Children's Hospital Association Case Mix database between January 2004 and September 2012. Subsequent hospitalizations, hospital days, readmissions, and costs of hospital care were assessed over the 12-month period after the initial hospitalization. Nonparametric Wilcoxon signed rank tests were used for comparisons between HH and non-HH users.

RESULTS: Although HH cases had a higher percentage of complex chronic conditions (68.5% vs 65.4%), technology assistance (40.5% vs 35.7%), and neurologic impairment (40.7% vs 37.3%) than matched controls ($P \leq .003$ for all), 30-day readmission rates were lower in HH patients (18.3% vs 21.5%, $P = .001$). At 12 months after the index admission, HH patients averaged fewer admissions (0.8 vs 1.0, $P < .001$), fewer days in the hospital (6.4 vs 6.6, $P < .001$), and lower hospital costs ($22 511 vs $24 194, $P < .001$) compared with matched controls.

CONCLUSIONS: Children discharged to HH care experienced less hospital use than children with similar characteristics who did not use HH care. Further investigation is needed to understand how HH care affects the health and health services of children.

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WHAT'S KNOWN ON THIS SUBJECT: There is increasing attention to the use of home health care for children with medical complexity. However, little is known about the extent to which home health services influence hospital resource use in this population of children.

WHAT THIS STUDY ADDS: Hospitalized children discharged to home care services experienced fewer readmissions and subsequent hospitalizations than similar children not receiving such services. The use of postdischarge home health services may reduce subsequent use of hospital resources, particularly for children with medical complexity.

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The population of children with medical complexity is growing throughout the United States, accounting for a large and increasing proportion of pediatric care.[1,2] These children have lifelong, complex chronic conditions (CCCs) that are often associated with significant functional impairment, myriad healthcare needs, and high resource use.[3–5] Health care spending for these children is largely dominated by their hospital care[6]; minimizing it is a major focus of U.S. population-based cost containment efforts.[7] It is hoped that the children's transitions from the hospital to high quality outpatient, community, and home care management will optimize their health and contain healthcare costs.

Home health nursing care (HH) is often an integral component of care for children with complex medical conditions and offers the potential to reduce hospital use. HH encompasses a wide range of health care services that can be given in a patient's home for an illness or injury. For some patients, HH can be a less expensive, more convenient and equally effective alternative to care delivered in a hospital or postacute care facility.[8] Readmission reductions are reported in studies of HH for postpartum women and older adults.[9–12] However, little information is available on the influence of HH services for the pediatric population. Paul, et al[12] found that HH was safe and effective after discharge from maternity and newborn care. Home visits by nursing personnel might be particularly beneficial for children with complex medical conditions, who are at high risk for recurrent use of hospital care over time.[1,2]

Pediatric HH falls into 2 distinct types: "intermittent skilled nursing visits" (SNV) and "private duty nursing" (PDN). SNVs aim to teach and support families/caregivers toward the goal of independence at home. With SNV, a nurse may coordinate a home care plan with the family or health care team and perform laboratory work, infusion therapy, or blood glucose monitoring. SNVs are typically short, intermittent, and time-limited. PDN (also known as "extended hour care," "shift care," or "in-home" nursing) typically aims to replace the need for long-term hospitalization or institutionalization. For example, a PDN may implement the care plan for children with medical complexity (eg, tracheostomy/ventilator dependency) who otherwise could not live safely at home. PDN services are often provided on an extended basis (eg, 24 hours per day) for many months or years.

Despite the growing use of HH services,[7,13] little is known about the extent to which they influence hospital resource use in children. Therefore, the objective of this study was to assess the impact of postdischarge HH services on future hospital use. We hypothesized that children discharged to HH services would use fewer hospital resources over time compared with matched children not receiving HH services after discharge.

METHODS

Data Sources

HH and hospital data were obtained from billing records of BAYADA Home Health Care (Moorestown, NJ) and the Case Mix database from the Children's Hospital Association (Overland Park, KS), respectively. Case Mix is an inpatient administrative database from 97 hospitals in 37 states. For each admission, Case Mix includes information on demographics, cost, and *International Classification of Diseases, Ninth Revision, Clinical Modification* diagnosis and procedure codes. Deidentified, encrypted identifiers allow children to be tracked across hospitalizations at the same hospital. The BAYADA database includes administrative, demographic, clinical, and reimbursement information for children using BAYADA HH services from 19 states in all geographic regions. BAYADA's standard operating model infuses consistency of care across regions and states.

Study Population and Design

Using birth date, sex, and zip code, we identified 3516 children discharged for the first time (ie, index hospitalization) from 52 Case Mix children's hospitals to BAYADA HH between January 1, 2004 to September 30, 2012. Each child was matched with up to 3 controls within the same Case Mix hospital who were not discharged to HH (using discharge disposition codes) but who had the same (1) age in days (within ±10%); (2) number and type of CCCs[3]; (3) reason for and severity of hospitalization, determined with All-Patient Refined-Diagnostic Related Groups (3M, Health Information Systems, Wallingford, CT); and (4) race/ethnicity. CCCs, identified with *International Classification of Diseases, Ninth Revision, Clinical Modification* codes, include conditions expected to last >12 months and involve either several different organ systems or 1 organ system severely enough to require specialty pediatric care and hospitalization.[3] CCCs include medical technology to maintain a child's health status (eg, gastrostomy, tracheostomy).[14,15]

Controls were identified for 2783 (79.2%) children within the same hospital; 2124 (76.3%) had 3 controls, 330 (11.9%) had 2, and 329 (11.8%) had 1. In the final cohort, these 2783 patients discharged to BAYADA HH were matched to 7361 control patients who were discharged from the hospital without HH services (Fig 1). Each patient had only 1 index hospitalization included for analysis; patients were represented only 1 time in the analytic dataset. We used matching to directly compare outcomes between cases and controls with similar demographic and clinical characteristics within the same hospital and to optimize statistical power by using multiple controls for each case when possible.

Main Outcome Measures

For 12 months after discharge from each index hospitalization between January 1, 2004 and September 30, 2012, we assessed the number of hospitalizations, hospital bed days, hospital cost, and all-cause hospital readmissions within 30 days for HH patients and matched controls. Hospital costs, inflated to 2015 dollars, were estimated in the Case Mix database by multiplying overall patient charges by hospital-specific cost to charge ratios.[16]

Statistical Analysis

All categorical variables were summarized using frequencies and percentages. Nonparametric Wilcoxon signed rank tests were used to determine statistical differences in the main outcomes between HH cases and controls. We also stratified this analysis by type of CCC and by neonates (<30 days old at index admission) versus nonneonates. SAS 9.3 (SAS Institute, Inc, Cary, NC) was used for all analyses. For demographic data in Table 1, population differences with *P* values less than a Bonferroni-adjusted significance level of 0.003 were considered statistically significant. For all other data shown, $P < .05$ was considered statistically significant. This study was not considered human subjects research in accordance with the policies of the Vanderbilt University institutional review board.

RESULTS

Demographic and Clinical Characteristics

Median age at index admission was 2.7 years (interquartile range

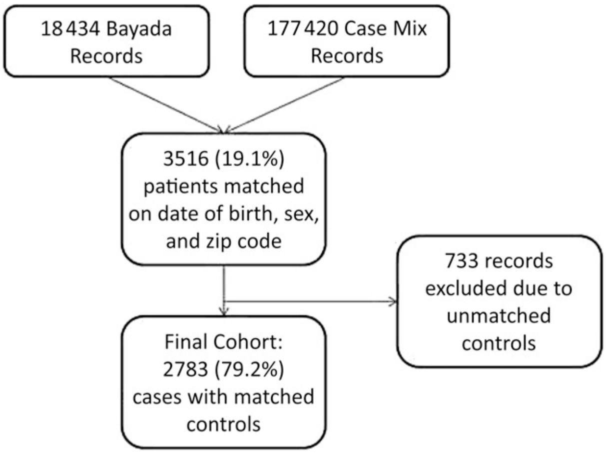

FIGURE 1
Flow diagram for merging BAYADA and Case Mix databases.

TABLE 1 Demographic and Clinical Characteristics of Hospitalized Children Discharged to HH Services and Their Matched Controls

Characteristics	HH Cases *N* (%)	Non-HH Controls *N* (%)	*P*[a]
N	2783	7361	
Age at admission of index hospitalization			
<30 d	573 (20.6)	1806 (24.5)	<.001
30 d to 1 y	456 (16.4)	1249 (17)	
1–5 y	633 (22.8)	1562 (21.2)	
5–12 y	500 (18)	1277 (17.4)	
12–17 y	621 (22.3)	1467 (19.9)	
Race/ethnicity			
Non-Hispanic white	1715 (61.6)	4585 (62.3)	.93
Non-Hispanic black	458 (16.5)	1160 (15.8)	
Hispanic	326 (11.7)	855 (11.6)	
Asian	38 (1.4)	97 (1.3)	
Other	246 (8.8)	664 (9.0)	
Payor			
Private	1500 (53.9)	3197 (43.4)	<.001
Government	1157 (41.6)	3193 (43.4)	
Other payor	126 (4.5)	971 (13.2)	
CCCs[b]			
Any CCC	1907 (68.5)	4816 (65.4)	.003
Cardiovascular	523 (18.8)	1333 (18.1)	.43
Neuromuscular	1025 (36.8)	2564 (34.8)	.06
Respiratory	448 (16.1)	1043 (14.2)	.01
Renal	178 (6.4)	427 (5.8)	.26
Gastrointestinal	925 (33.2)	2256 (30.7)	.01
Hematology and immunodeficiency	102 (3.7)	225 (3.1)	.12
Metabolic	238 (8.6)	527 (7.2)	.02
Other congenital or genetic defect	604 (21.7)	1527 (20.7)	.29
Malignancy	54 (1.9)	110 (1.5)	.11
Number of CCCs			
0	876 (31.5)	2545 (34.6)	.006
1	760 (27.3)	2025 (27.5)	
2	537 (19.3)	1359 (18.5)	
3+	610 (21.9)	1432 (19.5)	
Technology assistance	1128 (40.5)	2624 (35.7)	<.001
Neurologic impairment	1133 (40.7)	2747 (37.3)	.002

[a] *P* values were determined from χ^2 tests.
[b] The rows of data for CCCs are not mutually exclusive; therefore, *P* values were calculated for each category to show comparisons between cases and controls.

TABLE 2 Index Hospitalization Characteristics of Hospitalized Children Discharged to HH Services and Their Matched Controls

Characteristics	HH Cases	Non-HH Controls	P[a]
Hospital resource use[b]			
Length of stay (d)	4 (2–11)	3 (2–10)	<.001
Hospital cost	$9436 ($3756–$32 502)	$6541 ($2770–$21 815)	<.001
Most common major diagnostic categories of index admission[c]			
Newborn care	498 (17.9%)	1550 (21.1%)	<.001
Nervous system	421 (15.1%)	1102 (15.0%)	.87
Respiratory system	413 (14.8%)	964 (13.1%)	.02
Musculoskeletal system	279 (10.0%)	679 (9.2%)	.23
Digestive system	272 (9.8%)	718 (9.8%)	.98

[a] P values were determined from Wilcoxon signed rank test for hospital resource use and from χ^2 tests for major diagnostic categories.
[b] Shown are median values (IQR).
[c] N (% of total cohort).

[IQR], 0.2–11 years) for HH cases and 2.2 years (IQR, 0.1–10 years) for controls. HH cases had a smaller percentage of neonates (age <30 days) than controls (20.6% vs 24.5%, $P < .001$). Race/ethnicity did not vary significantly between children discharged to HH and controls ($P = .9$); both HH cases and controls were predominately non-Hispanic white (61.6% vs 62.3%). HH cases had a higher percentage of CCCs (68.5% vs 65.4%, $P = .003$), technology assistance (40.5% vs 35.7%, $P < .001$) and neurologic impairment (40.7% vs 37.3%, $P = .002$). Neuromuscular and gastrointestinal CCCs were the most prevalent among HH cases and controls. A greater percentage of HH cases used private insurance (53.9% vs 43.4%, $P < .001$) (Table 1).

Index Hospitalization Characteristics

Conditions affecting newborns and nervous, respiratory, and musculoskeletal system problems were the most common reasons for hospitalization. These problems accounted for 57.9% and 58.4% of index hospitalizations for HH cases and controls, respectively (Table 2). Pneumonia/bronchiolitis, seizure, and hip and femur procedures were among the most common specific reasons for index admission in HH cases and controls. Compared with controls, HH cases had longer index hospitalization lengths of stay (median 4 days [IQR, 2–11 days] vs 3 days [IQR, 2–10 days], $P < .001$] with higher costs (median $9436 [IQR, $3756–$32 502] vs $6541 [IQR, $2770–$21 815], $P < .001$) (Table 2).

Home Health Nursing Characteristics

Of HH cases, 92.0% ($n = 2561$) used PDN and 8.0% ($n = 222$) used exclusively SNV. In the 12 months after index hospitalization, HH cases received a median of 2.0 hours (IQR, 1.0–33.2 hours) per week for a median of 4.0 weeks (IQR, 2.0–23.3 weeks). The median total HH payment per patient was $3816 ($488–$44 006). The highest and lowest median payments were observed in children with a respiratory CCC (median, $82 833 [IQR, $12 474–$177 292) and a malignancy CCC (median, $3789 [IQR, $250–$28 406]), respectively.

Exposure to HH and Subsequent Hospital Resource Use

During the study period, the 2783 HH cases experienced 2311 subsequent hospitalizations within 12 months of discharge; the 7361 controls experienced 7365 subsequent hospitalizations.

Readmissions

For the entire cohort, the 30-day readmission rate after discharge from the index hospitalization was lower in HH cases than in controls (18.3% vs 21.5%, $P = .001$) (Table 3). HH cases also had a lower 15-day readmission rate (data not shown). Findings by CCC revealed that some of the largest differences in 30-day readmission rates for HH cases versus controls occurred in children with a respiratory CCC (30.6% vs 41.1%, $P < .001$) or a neuromuscular CCC (22.4% vs 29.9%, $P < .001$) (Table 3). When stratifying the readmission analyses by neonates versus nonneonates, a lower readmission rate was observed for nonneonates only (Fig 2).

Number of Hospitalizations

At 12 months, HH patients averaged 17% fewer admissions than their matched controls (0.83 [SD, 1.67] vs 1.00 [SD, 1.82], $P < .001$]. HH cases also had fewer admissions within 6 months (data not shown). Findings by CCC revealed that some of the largest differences in the number of admissions for HH cases versus controls occurred in children with a respiratory CCC (1.5 vs 2.1, $P < .001$) or a neuromuscular CCC (1.0 vs 1.4, $P < .001$) (Table 3). When stratifying the number of admissions within 12 months by neonates versus nonneonates, fewer admissions were observed in nonneonates only (Supplemental Tables 4 and 5).

Hospital Bed Days and Cost

HH cases had fewer hospital days than controls in the 12-month period after discharge from index hospitalization (mean, 6.4 days [SD 20.7] vs 6.6 [SD 18.6] days, $P < .001$] (Table 3). HH cases also had a lower mean cost per patient for subsequent hospital care over 12 months (mean, $22 511 [SD $85 095] vs $24 194 [SD $76 143], $P < .001$] Findings by CCC revealed that some of the largest differences in hospital days and costs for HH cases versus controls occurred in children with a respiratory or neuromuscular CCC (Table 3). When stratifying the hospital days and costs

TABLE 3 One-Year Hospital Resource Use After Index Hospitalization Discharge Using HH Care and Matched Controls by Type of CCC

Patient Group	Total Patients		30-Day Readmissions (%)		Hospital Resource Use Within 1yr After Discharge[a]					
					No. Hospitalizations		Hospital Days		Hospital Costs[b]	
	HH	Non-HH	HH	Non-HH	HH	Non-HH	HH	Non-HH	HH	Non-HH
All Patients	2783	7361	18.3*	21.5	0.8**	1.0	6.4**	6.6	$22 511**	$24 194
Any CCC	1906	4787	23.7**	29.6	1.1**	1.4	9.0**	9.7	$31 977**	$36 097
Cardiovascular	523	1333	33.1*	38.5	1.7	1.9	17.6	17.8	$70 382*	$73 480
Neuromuscular	1025	2564	22.4**	29.9	1.0**	1.4	8.8**	9.7	$30 655**	$34 407
Respiratory	448	1043	30.6**	41.1	1.5**	2.1	16.0**	18.8	$61 669**	$71 856
Renal	178	427	39.9	42	2.3	2.5	19.0	16.5	$65 941	$64 312
Gastrointestinal	925	2256	29.5**	38.7	1.5**	1.9	13.2**	15.3	$47 444**	$56 124
Hematology and immunodeficiency	102	225	44.1	38.5	2.5	2.7	21.7	18.6	$75 128	$73 497
Metabolic	238	527	31.1	35.7	1.7	2.1	14.6	13.5	$48 378	$51 749
Congenital/genetic	604	1527	26.5	30.7	1.3**	1.6	11.6*	11.2	$43 349*	$43 763
Malignancy	54	110	55.6	66.7	4.1	5.0	32.5	26.9	$108 795	$90 068

[a] Data shown represent means for the respective comparisons.
[b] Costs were determined for all patients, including those who had no subsequent hospitalizations after the index admission.
* P value range, .001–.05.
** $P < .001$.

by neonates versus nonneonates, less hospital resource use was observed in nonneonates only (Supplemental Tables 4 and 5).

DISCUSSION

This retrospective matched cohort study suggests that use of HH after hospitalization for children is associated with less hospital resource use over time. When compared with matched controls, children discharged to HH had lower readmission rates, hospital days, and hospital costs over the following year. This finding occurred despite characteristics suggesting that HH cases may have been more complex or severe; HH cases had a higher prevalence of CCCs and technology assistance. When stratifying analyses by neonates versus nonneonates, different findings emerged. In neonates, hospital resource use was similar in HH cases and controls; in nonneonates, hospital resource use was lower in HH cases.

In the current study, 30-day readmission rates were high for children using HH and their matched controls (18% and 21%, respectively). These high rates likely indicate the high medical acuity and fragility of both patient groups. Similar readmission rates have been reported in children with CCCs, including those with sickle cell disease and malignancies.[17] Our finding of fewer readmissions in children using HH contrasts with Feudtner et al,[18] who found that HH was not associated with decreased risk of readmission within 1 year. There are several reasons to explain the difference in findings. The study by Feudtner et al[18] did not compare HH with matched controls and it was not restricted to 1 HH provider. By reducing the variation across HH providers, our focus on a single entity (ie, BAYADA) was positioned differently to assess HH benefits.

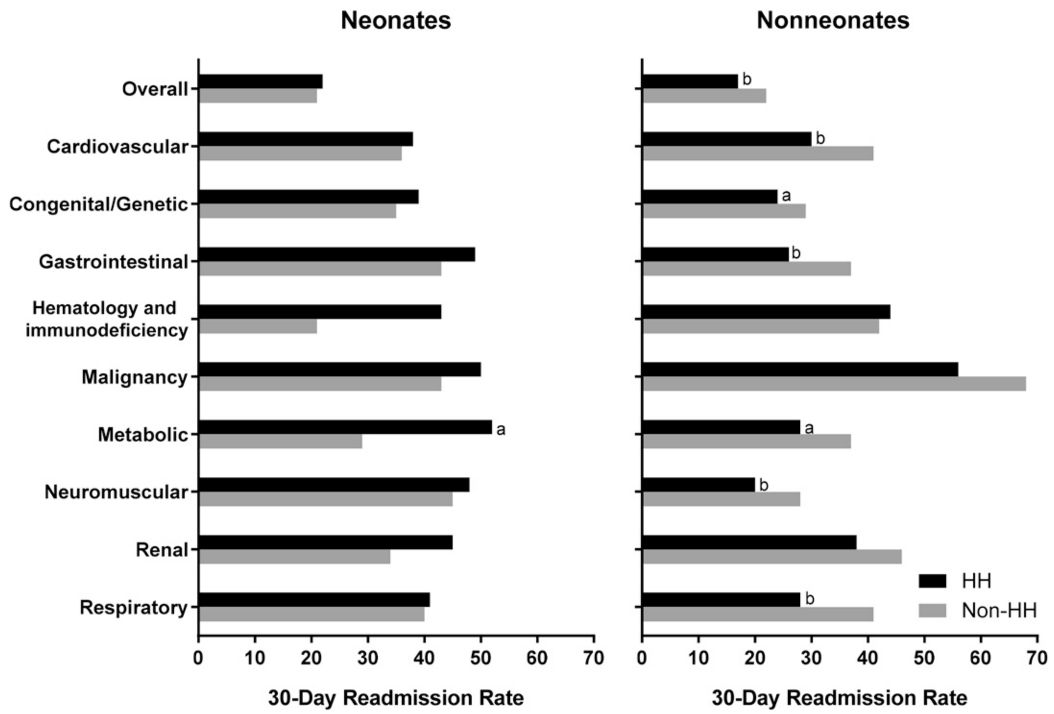

FIGURE 2
Readmissions after index hospitalization discharge for HH and matched controls by type of CCC. Shown are the 30-day all-cause readmission rates after index hospitalization for HH cases (in black) and controls (in gray). The bars labeled "overall" refer to a child with any CCC. Neonates are infants <30 days of age at index admission. The asterisks on the bars indicate statistically significant differences in readmission rate between HH cases and controls (**P* < .001; ***P* value range, .001–.005).

Further investigation is needed to determine why HH was associated with lower hospital resource use over time. HH may provide both anticipatory guidance and early direct treatment of health decline for children with CCCs, thus alleviating their need for hospitalization. Of course, these children could receive this type of care in a variety of different settings with other providers (eg, primary care physician in a medical home or case manager in the community) that we could not measure in this study. Future studies may wish to explore how quickly HH is equipped to respond to the children's health needs when compared with primary and other types of care. Children with CCCs are particularly vulnerable to rapidly developing, severe manifestations of acute and chronic illnesses that, without prompt attention, often result in recurrent, lengthy hospitalizations.[19] Therefore, HH may be particularly effective at limiting hospital use for these children.

It is believed that a small percentage (<2%) of children with CCCs receive HH.[3] Population health initiatives with shared savings among providers across the care continuum should assess whether cost savings from a modest reduction in hospital use could support expansion of HH.[3] Although our findings of reduced hospital resource use with HH support this possibility, they should be interpreted with caution. The current study is not positioned to assess the impact of HH on total healthcare spending. The databases used do not contain the outpatient, community, emergency department, or other health services data necessary to assess this impact. Moreover, the payments made for HH reported in the current study are not equivalent to the reported costs for hospital care. Future studies should strive to compare the same type of financial data (eg, cost or payment) across the care continuum when assessing the impact of HH in children.

There are several reasons that might help explain why the relationship between HH and hospital resource use differed between neonates and nonneonates. Perhaps the clinical trajectory of the neonates' CCCs influenced their need for hospital care beyond the capability of HH to affect it. For example, regardless of whether HH was used, some of the neonates may have required subsequent hospital care for treatments to maintain their health and functioning. It is possible that the neonatal period of time for infants with CCCs is associated with a less "stable" clinical status that, for some, tends to settle as the infants advance in age. Subsequent studies may wish to assess how much this suspected clinical stability plays a role in the impact of HH on children with CCCs.

This study has several other limitations. The cases receiving home health services were identified by their first encounter with BAYADA HH. Some patients could have received previous HH from another provider. Also, patients in the control group may have received HH after hospital discharge that we could not detect using the discharge disposition information available in the Case Mix database. We were unable to distinguish the true reasons for HH use, including the need for respiratory, enteral, or parenteral therapies and treatments. Readmissions to a different hospital are not included in the Case Mix database, which could have led to undercounting of readmissions for cases and controls. Absent the availability of patient name and medical record number, BAYADA patients were identified in the Case-Mix database using sex, birthdate, and zip code; this identification process may have been imprecise for some patients.

Despite a robust attempt to match HH cases and controls for complexity and severity, there could have been unaccounted differences. For example, the type of insurance varied for HH cases and controls. In a post hoc analysis, we stratified the relationship of HH with hospital resource use by payor. We found that HH was associated with lower resource use in both children with public and private insurance (data not shown). HH cases and controls were not matched specifically on the exact timing of the index admission because too few matches would have been found. Nevertheless, most cases and controls were matched during a similar time period (eg, recent HH cases were matched with recent controls). Although we matched HH cases and controls within the same hospital, there could still be practice variation across regions that could affect the findings. HH cases and controls were not explicitly matched by age of onset of CCC because the administrative data were not designed to distinguish this. However, the cardiovascular CCC category, comprised mostly of patients with congenital heart disease, likely had an onset during gestation. Matching HH cases and controls by age for children with a cardiovascular CCC helped compare children at their onset of disease (ie, closer to birth) or later in life (ie, farther out from birth) depending on when their index admission occurred.

These limitations provide motivation for further studies to assess the impact of HH services. The findings from the current study suggest that HH may influence hospital use of children with CCC, leading to a reduction in hospital readmissions, admissions, total hospital days, and costs. Shifting care to nonhospital environments may have the potential for significant cost savings for hospitals and integrated medical systems. For the family, care for the child with medical complexity in the home environment may provide greater comfort and satisfaction. Fewer missed days of work, reductions in travel time and expense, and the reassurance of familiar surroundings are all potential benefits for patients and/or family members.

Future investigations should explore prospective analyses with rigorous designs (eg, randomization or pre–post test designs with a control group) to truly assess the impact of HH on hospital use for children. Additionally, although the majority of BAYADA patients in this study received PDN, some patients also benefited from episodic SNV, and the impact of these specific services should be studied in more detail. Because patients with medical complexity have variable health care needs often over the span of many years, it would also be valuable to follow patients beyond a 12-month time frame. Furthermore, an all-encounter dataset, such as Medicaid claims data, would allow much needed assessment of the true impact of HH across the entire spectrum of care, including outpatient visits for primary and subspecialty care as well as emergency department and inpatient care.

CONCLUSIONS

Hospitalized children with CCCs discharged to HH experienced fewer short-term readmissions, subsequent hospitalizations, and lower hospital costs over a 12-month period than matched controls of children with similar attributes who were not discharged to HH. The use of postdischarge HH may help to limit subsequent use of hospital resources, particularly for children with complex medical conditions.

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ABBREVIATIONS

CCC: complex chronic condition
HH: home health nursing care
IQR: interquartile range
PDN: private duty nursing
SNV: skilled nursing visit

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