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MAJOR ARTICLE

Predictors of Unplanned Hospitalization in Patients Receiving Outpatient Parenteral Antimicrobial Therapy Across a Large Integrated Healthcare Network

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Background. Outpatient parenteral antimicrobial therapy (OPAT) prescribing has increased along with the trend toward early discharge of hospitalized patients who have infections. There is limited literature that assesses unplanned hospitalizations during OPAT. This study aims to elucidate the predictors of unplanned hospitalization in OPAT patients after discharge from acute-care facilities within Carolinas HealthCare System (CHS). Understanding these predictors may inform future interventions to improve treatment efficacy and patient outcomes.

Methods. The study cohort included hospitalized patients aged >19 years who initiated OPAT in an acute-care facility within CHS in 2014–2015. Patients who had OPAT prescribed at an ambulatory-care facility were excluded. The primary outcome was unplanned hospitalization anytime during the at-risk time from discharge through 90 days.

Results. The unplanned hospitalization rate for the cohort was 18.5%. In adjusted analysis, having OPAT delivered at a skilled nursing facility was associated with a 46% (incident risk ratio = 1.46; 95% confidence interval = 1.04–2.06) increased risk of an unplanned hospitalization compared with patients receiving OPAT at home after adjustment for demographics, comorbidities, indication, treatment duration, and antimicrobial prescribed. Infusion, dialysis, and rehabilitation centers had the lowest rates of unplanned hospitalizations.

Conclusions. These results suggest that the location of OPAT delivery is associated with unplanned hospitalizations and that older patients need additional support during OPAT.

Keywords. antimicrobial; hospitalization; infusion; outpatient parenteral antimicrobial therapy (OPAT).

Outpatient parenteral antimicrobial therapy (OPAT) is one alternative to completion of longer-term inpatient intravenous antimicrobial therapy in patients hospitalized with infections [1, 2]. The goal of OPAT is to allow patients to return home and safely complete their therapy while avoiding the inconvenience and expense of prolonged hospitalization [3, 4]. With OPAT, antibiotics may be administered in the home by either a home health provider or the patient, at an infusion center, or at a long-term care facility [1].

Several small studies from Minneapolis, Oregon, and Canada between 1978 to 1982 suggested that home infusion of antimicrobials was feasible in a select group of less severely ill patients [5–9]. By 1998, growth of OPAT reached 250 000 patients, and cost was estimated at $2 billion annually [10]. Since that time, OPAT has sustained growth of more than 10% annually [11]. Guidelines that were released from the Infectious Diseases Society of America (IDSA) in 2004 suggest that OPAT is effective for a wide variety of infections [1]. As the US population ages and healthcare reform evolves, OPAT utilization is expected to continue to increase. Pressures on hospitals to reduce their overall costs while improving the quality of care are escalating. As a result, hospitals may discharge more patients with OPAT to shorten the length of stay, given that OPAT is considered a safe alternative.

Outpatient parenteral antimicrobial therapy is not without risk and may not be appropriate for all patients. One study found that up to 24% of patients experienced complications during the course of treatment, even with advances in mechanical infusion devices [12, 13]. Infectious Diseases Society of America guidelines recommend selecting only those patients for OPAT who have the physical capacity and resources available to complete the therapy successfully outside of the hospital setting. In addition to IDSA guidelines on patient selection, the payer source, geography, and resources are also factors in deciding where a patient receives OPAT once discharged [1, 14, 15]. In the United States, the majority of patients self-administer OPAT in the home with a single teaching session from a home health nurse

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visit and coordination of medication delivery with a specialty pharmacy [15]. Few studies have focused on which factors are most important in selecting patients best suited for OPAT to prevent unplanned hospitalizations [16, 17]. Unplanned hospitalizations are burdensome to patients and their caregivers. In addition, acute-care facilities may experience penalties related to the unplanned hospitalization. Therefore, prevention of complications, successful completion of OPAT, and resolution of infection benefit patients, caregivers, and the healthcare facility.

This study aimed to elucidate the predictors of unplanned hospitalization after OPAT initiation upon discharge from an acute-care facility. By understanding these predictors, we may be able to improve patient outcomes through better patient selection and tailored support. Such information could be an important addition for treatment recommendations such as those proposed by Muldoon et al, which include appropriate patient selection, infectious disease consultation, patient/caregiver education, discharge planning, outpatient monitoring/tracking, and regular OPAT program review [18].

METHODS

Data Source

All data used in this study were collected in a REDCap database that was built as part of an OPAT monitoring program that began on October 13, 2014, across CHS facilities [19]. The study period spanned from the implementation of the OPAT database until December 31, 2015. Collection included a standard OPAT order set that was used by providers to enter antibiotic orders and that provided guidance on recommended lab monitoring. Patients with an OPAT order were followed from the time of inpatient discharge (index discharge) to their last follow-up visit after completion of OPAT. Data elements were collected either electronically or by provider entry into REDCap and included patient demographics, treatment indication, antibiotic prescribed, reasons for changes to the prescribed course, infusion location (home, skilled nursing facility, infusion center, or dialysis center), complications with the access device, type of access device, treatment duration in days, and days to the first follow-up visit after the discharge to OPAT. Data elements were collected over the entire OPAT treatment course and follow-up period.

Selection of Patients

Patients who were aged >19 years who were discharged from CHS and who had an OPAT order were extracted from the RedCap database (n = 2448). Patients who had OPAT prescribed at an ambulatory care facility (n = 220) were excluded (final unplanned hospitalization study cohort n = 2228) (Figure 1). Of these 2228 patients, 413 (18.5%) had an unplanned hospitalization, 54 (2.4%) died within 90 days of discharge, and 202 (9.7%) did not have a follow-up visit with an infectious disease provider within 90 days of discharge. This study received CHS institutional review board approval (no. 04-16-12E).

Description of the Outcome Variable and At-Risk Time

The primary outcome, unplanned hospitalizations, was defined according to the National Home Infusion Assocation guidelines as "an active infusion patient requires an unplanned, inpatient admission to an acute-care hospital for any reason" [20]. Patients were considered at risk of an unplanned hospitalization from the time of the index discharge to the date of unplanned hospitalization. Patients who died or were not hospitalized were censored at the date of death or 90 days after discharge, respectively.

Definitions for Predictors and Descriptive Variables

To determine which patients may have died outside of the hospital, social security death records were used to obtain the date of death. Race and gender were self-reported measures. Age was determined at the time of discharge. The Charlson comorbidity index score was calculated and used to control for comorbidities and was determined at the time of discharge [21]. Modification to a course of treatment was defined as de-escalation of therapy, stopping of treatment, or extension of treatment. Reasons for modification included adverse drug reactions or other reason (noncompliance, discharge to hospice, and worsening infection).

Adverse drug reactions included rash, acute kidney injury (AKI), hematologic abnormality, drug toxicity, and other in RedCap. Acute kidney injury was determined by the provider based on a rise in serum creatinine of at least 0.3 mg/dL or >1.5–2-fold from baseline [22]. Indications for treatment were selected by the provider when the OPAT order was placed. Treatment duration was calculated as the number of 24-hour intervals from the start date of the infusion to the stop date of the infusion. Frequency of treatment was documented in RedCap.

Access-line patency issues were documented as "mechanical failure" in RedCap and did not include deep vein thromboses events, which were documented separately. Adverse events related to the access line were documented separately as phlebitis, superficial line infection, secondary bacteremia, or other. The location of OPAT delivery was determined before discharge and documented in RedCap. Locations for OPAT included the patient's home, skilled nursing facility, infusion center, dialysis center, or rehabilitation facility.

Loss to follow-up was assumed if the patient did not have a documented visit with an infectious disease provider within the 90-day period after discharge. These visits, if the patient was seen by a CHS infectious disease provider, were available in the electronic health record and captured in RedCap. The time to the first follow-up visit was the number of days between the discharge date and the date of the first return visit to the infectious disease provider.

Statistical Analysis

This study used a retrospective cohort study design. The primary aim was to identify variables associated with unplanned

hospitalization any time from discharge on OPAT through 90 days after the patient's discharge date. In unadjusted analyses, differences between patients with an unplanned hospitalization and those without were tested by Wilcoxon-type rank sum for ordinal categorical variables and χ^2 for categorical variables [23] (Table 1). The same tests were used to compare patients with unplanned hospitalizations at 3 days, 4–30 days, and 31–90 days (Supplementary Table 1*A*). The Wilcoxon-type rank sum for ordinal categorical variables and χ^2 for categorical variables were also used to compare patients who developed AKI with those who did not have this adverse event (Table 2).

One multivariable model was constructed for predicting unplanned hospitalizations. A Poisson model using Huber-White robust standard errors and reporting incident risk ratios (IRRs) was used to determine the risk of having an unplanned hospitalization during OPAT treatment [24]. The Poisson model was adjusted by the at-risk exposure time from discharge to the unplanned hospitalization, with patients who died right-censored (Table 3). A Poisson model was selected because it offered direct estimation of the risk associated with an event. The significance level was chosen to be $\alpha = .05$ for all analyses. Predictors were selected based on literature review and discussions with infectious disease providers about their experience with patients returning to acute care after being discharged on OPAT.

RESULTS

Of the 2228 patients studied, the majority were aged >51 years, and the majority were white (Table 1). Most patients received OPAT at home, followed by skilled nursing center, infusion center, dialysis center, and acute rehabilitation facility (Table 1). Most patients completed their prescribed course of treatment without any modification (Table 1). Treatment duration of 14–42 days was prescribed most often. The most frequent indication for OPAT was bacteremia, followed by cellulitis/wound infections. The classes of antimicrobials most often prescribed were cephalosporins followed by glycopeptides. Vancomycin was prescribed to 443 persons (19.9%) in the study cohort.

Unadjusted Analyses

Unplanned Hospitalization

Of patients receiving OPAT, 413 (18.5%) had an unplanned hospitalization during the at-risk period. Of patients with an unplanned hospitalization, 52.4% received OPAT at home, whereas 31.2% received OPAT at a skilled nursing facility. Patients who had an unplanned hospitalization tended to be older, had higher Charlson comorbidity index scores at discharge, and were more likely to have OPAT at a skilled nursing facility. The antimicrobial class, gender, race, and indication for the OPAT did not significantly differ between groups. The lowest rates of readmissions in patients aged >70 years were from infusion and rehabilitation centers and the greatest rates were from home and skilled nursing centers. See Table 1.

Table 1. Characteristics of Patients in the Study Cohort Prescribed Outpatient Parenteral Antimicrobial Therapy

Variable	Overall (n = 2228)	Unplanned Hospitalization: No Unplanned Hospitalization (n = 1815)	Unplanned Hospitalization (n = 413)	*P* value
Male sex	57.7	59.2	52.3	.01
Age, y				
19–30	7.3	7.5	6.5	.50
31–40	8.4	8.7	7.5	.44
41–50	16.1	17.7	10.4	<.001
51–60	23.1	23.0	23.7	.75
61–70	23.9	23.4	25.9	.28
>70	21.1	19.8	25.9	.007
Race				
White	74.1	74.3	73.4	.93
Black/African American	20.5	20.3	21.1	
Unknown	5.4	5.4	5.6	
Treatment duration, d				
<14	33.1	32.1	37.0	.07
14–42	56.9	57.5	54.8	.35
>42	9.9	10.4	8.2	.18
OPAT course modified/reason				
No modification	84.7	85.0	83.8	.38
Adverse drug reaction	1.0	1.0	1.2	
Change in antibiotics	3.6	3.5	4.4	
Therapy extended	7.2	7.5	6.1	
Other reason	3.4	3.1	4.6	
OPAT infusion location				
Home	61.4	63.9	52.4	<.001
Skilled nursing facility	23.1	20.9	31.2	
Infusion center	7.6	7.9	6.4	
Dialysis center	3.0	2.8	3.9	
Rehabilitation facility	4.9	4.5	6.1	
Indication for OPAT				
Cellulitis/wound infection/abcess	20.5	20.9	19.2	.68
Postoperative infection	19.3	20.2	16.2	
Bacteremia	20.9	20.1	24.2	
Osteomyelitis	18.3	18.3	18.5	
Urinary tract infection	6.2	6.0	6.9	
Endocarditis	4.5	4.5	4.6	
Other	10.1	10.1	10.4	
Antibiotic class				
Cephalosporins	34.8	34.1	38.0	<.001
Glycopeptides (vancomycin)	18.5	18.0	21.1	
Penicillins	7.0	6.8	8.0	
Aminoglycosides	0.9	0.9	0.7	
Carbapenems	13.4	12.3	18.2	
Lipopeptides (daptomycin)	7.3	7.3	7.3	
Other	18.1	20.7	6.8	
Had line patency issue, %	1.5	1.3	2.2	.21
Charlson comorbidity index at discharge, mean (SD)	5.5 (4.4)	5.2 (4.3)	7.0 (4.5)	<.001

P values by *t* test for continuous variables and χ^2 for binary/nominal variables. *P* values by nonparametric test for trend for ordinal variables (Wilcoxon-type rank sum, Cuzick 1985 [23].
Abbreviation: OPAT, outpatient parenteral antimicrobial therapy.

Table 2. Characteristics of Patients Who Developed Acute Kidney Injury During Treatment

Variable	Did Not Develop AKI (n = 2209)	Developed AKI (n = 19)	*P* value
OPAT infusion location, %			
Home	61.6	44.4	.02
Skilled nursing facility	22.7	55.6	
Infusion center	7.7	0.0	
Dialysis center	3.1	0.0	
Rehab center	4.9	0.0	
Treatment duration, d, %			
<14	33.3	15.8	.11
14–42	56.7	78.9	.05
>42	10	5.3	.49
Time to first follow-up visit after discharge, mean			
<7 days	63.6	52.60	.32
8–14 days	14.9	31.60	.04
>14 days	21.5	15.80	.55
Charlson comorbidity score at discharge, mean score (SD)	5.5 (4.4)	5.5 (4.6)	.96
Age category, y, %			
19–30	7.4	0.0	.22
31–40	8.5	0.0	.18
41–50	16.2	10.5	.51
51–60	23.0	36.8	.15
61–70	23.9	26.3	.81
>70	21.1	26.3	.58
Required an unplanned hospitalization, %	18.3	47.4	.001
Frequency of prescribed vancomycin, %	n = 427[a]	n = 16[a]	
< every 12 h	14.5	6.2	.35
every 12–24 h	36.8	62.5	.04
every 48–72 h	48.6	31.2	.17

P values by *t* test for continuous variables and χ^2 test for binary/nominal categorical variables. *P* values by nonparametric test for trend for ordinal variables (Wilcoxon-type rank sum, Cuzick 1985 [23].

[a]Of the 443 patients prescribed vancomycin, 16 developed acute kidney injury. Three patients with acute kidney injury were prescribed other medications, including piperacillin/tazobactam, ceftriaxone + gentamicin, and cefepime.

Unplanned Hospitalization By Time From Discharge to Hospitalization

Although there were no statistically significant differences in the groups of patients admitted at <3 days, 4–30 days, or 31–90 days, there were some trends worth noting. First, patients who came back within 3 days tended to receive OPAT for cellulitis or postoperative infection. Patients treated for bacteremia had unplanned hospitalization more frequently after 3 days from discharge. Patients with higher Charlson comorbidity index scores at discharge tended to have an unplanned hospitalization after 30 days. The analysis time extended to 90 days after discharge, but all patients who had an unplanned hospitalization returned within 60 days of their respective discharge date. Infusion centers had the lowest rates of unplanned hospitalizations in the unadjusted analyses. See Supplementary Table 1*A*.

Table 3. Predictors of Any Unplanned Hospitalization Within 90 Days after Discharge to Outpatient Parenteral Antimicrobial Therapy

Predictors	IRR	Robust (SE)	95% CI	*P* value
Male sex (referent: female)	0.72	0.10	0.54—0.95	.02
Age category, y (referent: 19–30)				
31–40	1.10	0.39	0.55–2.19	.80
41–50	0.61	0.21	0.31–1.20	.15
51–60	1.05	0.32	0.58–1.92	.87
61–70	0.89	0.28	0.48–1.65	.71
>70	0.90	0.30	0.47–1.73	.75
Race (referent: white)				
Black/African American	1.01	0.17	0.73–1.40	.96
Unknown	0.80	0.25	0.43–1.49	.47
Treatment duration (referent: <14 d)				
14–42	1.13	0.20	0.80–1.60	.495
>42	0.63	0.20	0.33–1.17	.14
Reason for modification of OPAT prescribed course (referent: no modification)				
Adverse drug reaction	1.47	0.71	0.57–3.79	.42
Change in antimicrobial	1.34	0.39	0.76–2.37	.31
Therapy extended	0.81	0.20	0.50–1.33	.41
Other reason	1.90	0.54	1.09–3.32	.02
Location OPAT was delivered (referent: home)				
Skilled nursing facility	1.46	0.25	1.04–2.06	.03
Infusion center	0.92	0.26	0.53–1.60	.78
Dialysis center	1.31	0.52	0.60–2.87	.499
Rehab center	1.32	0.42	0.70–2.48	.39
Indication for OPAT (referent: cellulitis/wound infection or abscess)				
Postoperative infection	0.88	0.21	0.55–1.41	.61
Bacteremia	1.11	0.24	0.72–1.70	.64
Osteomyelitis	1.10	0.26	0.70–1.74	.68
Urinary tract infection	1.06	0.35	0.56–2.02	.85
Endocarditis	0.80	0.33	0.35–1.79	.58
Other	0.84	0.22	0.49–1.42	.51
Antimicrobial class (referent: cephalosporins)				
Glycopeptides (vancomycin)	0.88	0.17	0.60–1.27	.49
Penicillins	0.90	0.26	0.51–1.58	.70
Aminoglycosides	1.59	0.96	0.48–5.21	.45
Carbapenems	1.02	0.23	0.66–1.59	.91
Lipopeptide (daptomycin)	1.06	0.29	0.62–1.79	.84
Other	3.27	1.02	1.77–6.04	<.001
Had line patency problem	2.29	0.90	1.06–4.96	.04
Charlson comorbidity index at discharge	1.05	0.02	1.02–1.08	.003

Poisson model with robust Huber-White standard errors reporting incident risk ratios. Poisson model adjusted by exposure=time at-risk of an unplanned hospitalization (days) from date of discharge to date of the unplanned hospitalization or death (censored). Time of analysis truncated at 90 days after discharge.

Abbreviations: CI, confidence interval; IRR, incident risk ratio; OPAT, outpatient parenteral microbial therapy; SE, standard error.

Acute Kidney Injury

Patients who developed AKI were either at home or in a skilled nursing facility, with the majority (55.6%) receiving OPAT at a skilled nursing facility. Patients with a treatment duration of 14–42 days were more likely to develop AKI. Dosing frequency of vancomycin at 12–24-hour intervals was most common

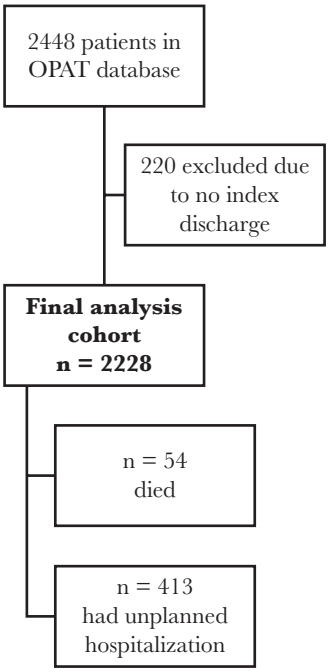

Figure 1. Study sample. Abbreviation: OPAT, outpatient parenteral antimicrobial therapy.

among AKI patients. Of those patients who developed AKI, 47.4% required an unplanned hospitalization. Age and Charlson comorbidity index score were not associated with AKI development in the unadjusted analyses. See Table 2.

Rates of Unplanned Hospitalization by Adverse Event

Acute kidney injury (n = 19) was the most frequently reported adverse event experienced by patients with an unplanned hospitalization within 90 days. Having any issue with their access catheter was the second most frequent adverse event in patients with an unplanned hospitalization. In patients with AKI, 7 of 10 (70.0%) patients who received OPAT at a skilled nursing facility had an unplanned hospitalization, whereas while 2 of 9 (22.2%) patients who recieved OPAT at home returned to the hospital. There were no reported cases of AKI from infusion, dialysis, or rehabilitation centers. The majority of patients who developed AKI while receiving OPAT in a skilled nursing facility and had an unplanned hospitalization had a dose frequency of 12–24 hours. Those at home who returned to the hospital with AKI were more frequently prescribed a <12-hour dosing schedule.

The majority of patients in our cohort had peripherally inserted central catheter (PICC) lines (92.5%), whereas 5.2% had subcutaneous ports, 2.1% had dialysis access, and 1 patient had a midline catheter (data not shown). Unplanned hospitalization

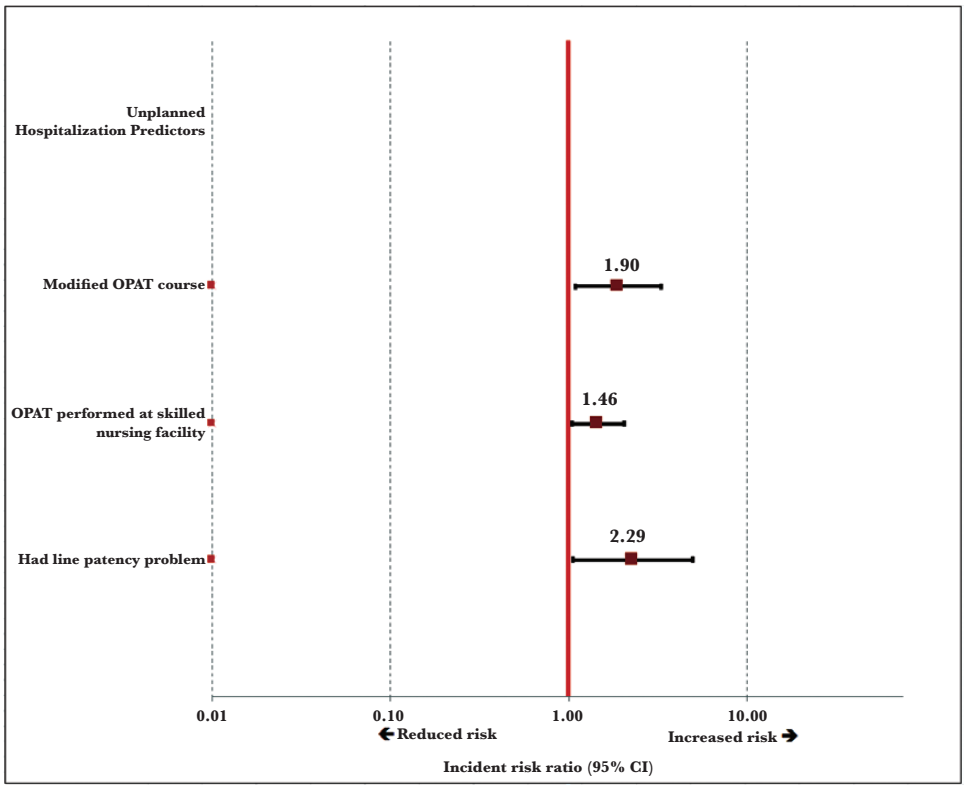

Figure 2. Forest plot predictors of unplanned hospitalization and early discontinuation. Abbreviations: CI, confidence interval; OPAT, outpatient parenteral antimicrobial therapy.

occurred in 22 of 62 (35.5%) of those patients who had any problem with their access device. Secondary complications associated with the access device were phlebitis, superficial line infection, and bacteremia. Rash was the most common adverse event reported but had a relative low rate of unplanned hospitalization (n = 4/23; 17.4%). See Supplementary Table 1*B*.

Adjusted Analyses

Unplanned Hospitalization Model

In adjusted analyses to evaluate unplanned hospitalization risk, receiving OPAT at a skilled nursing facility was associated with a 46% (IRR = 1.46; 95% confidence interval [CI] = 1.04–2.06) greater risk of having an unplanned hospitalization compared with receiving OPAT at home, after adjusting for patient demographics, treatment duration, course modification, indication, antimicrobial, line patency issues, and comorbidities. Patients with a line patency issue had a 2-fold greater risk (IRR = 2.29; 95% CI = 1.06–4.96) of an unplanned hospitalization than those without any issue. Finally, for every additional point increase in the Charlson comorbidity index score, the risk of having an unplanned hospitalization increased by 5% (IRR = 1.05; 95% CI = 1.02–1.08). See Table 3 and Figure 2.

DISCUSSION

Our study provides insight into specific risk factors that impact outcomes for patients receiving OPAT. One of the most significant findings in this study is that receiving OPAT at a skilled nursing facility versus home was associated with an increased risk of unplanned hospitalization. Although not significant in the adjusted model, infusion centers, dialysis centers, and rehabilitation centers had lower rates of unplanned hospitalizations. Based on a review of the literature, this study is the first to show that the location of OPAT delivery was associated with unplanned hospitalization.

After adjustment in the multivariable model, the increased risk of an unplanned hospitalization from a skilled nursing facility persisted. One specific factor that contributed to increased unplanned hospitalization was the increased risk of AKI. Of note, 10 of 19 (52.6%) patients that developed AKI were receiving OPAT in a skilled nursing facility. Of those, 7 of 10 (70%) required an unplanned hospitalization. Crotty et al suggests that patients transferred from hospitals to long-term care facilities may experience a gap in the continuity of care required to maintain medication schedules [25]. Crotty and colleagues also found that these patients were more likely to suffer adverse events and that placing a pharmacist transition coordinator in the skilled nursing facility improved patient outcomes for this vulnerable population [25].

Adverse drug reactions during OPAT therapy is an important topic in the literature [26–29]. In our study, the majority of patients who were readmitted secondary to an adverse reaction experienced AKI. Infectious Diseases Society of America guidelines recommend that patients on nephrotoxic antimicrobials have routine monitoring of kidney function. One study suggested that the lack of availability of laboratory test results is associated with higher rates of readmission for patients on OPAT [30]. Huck et al found that laboratory results were most often missing among patients receiving OPAT at home compared with those at skilled nursing facilities, dialysis centers, or infusion centers [30]. In addition, patients receiving OPAT at home and skilled nursing facilities may have barriers to getting appropriate laboratory checks, including issues with appropriate timing of trough levels or lack of timely results of trough results from reference labs. Our study supports previous concerns over increased risk of renal toxicity with OPAT, specifically an increased risk in skilled nursing facility and the home environment, and suggests the need for a change in strategy when prescribing nephrotoxic agents in these environments.

One study evaluated the impact of a pharmacist-led vancomycin monitoring program in the long-term care setting [31]. The goal was to reduce adverse events associated with vancomycin use in this specific setting. By using a pharmacist to oversee vancomycin monitoring, the incidence of AKI decreased from 16.3% to 4.7% over the course of 1 year [31]. Our results suggest that additional oversight may be warranted for patients as they transition from the acute-care hospital to a skilled nursing facility while taking a nephrotoxic drug.

This study found a strong association of the Charlson comorbidity index score with unplanned hospitalizations in our adjusted model. For each additional point increase, the risk of an unplanned hospitalization increased by 5%. Although perhaps it is not surprising that patients who have a higher Charlson index score also have a greater risk of an unplanned hospitalization, the Charlson index score should be considered as part of a decision tool to assist physicians in deciding the delivery venue and level of monitoring required to avoid unplanned hospitalizations.

There are several limitations to this study. First, OPAT prescriptions for patients included in the study database were prescribed by infectious disease physicians. As a result, our study findings may not be applicable for other provider types who prescribe OPAT. However, in the acute-care setting, an infectious disease consult is often obtained to guide OPAT treatment decisions. Even if an infectious disease provider did not prescribe the OPAT, he or she may have consulted with the patient's provider. Still, having all of our observations include infectious disease–prescribed OPAT cases may create bias because infectious disease physicians may be more familiar with OPAT and drug monitoring.

Second, we were unable to control for factors that may occur after discharge during the at-risk period. For example, patients discharged home may have several barriers to successful delivery of OPAT, such as financial or physical limitations, that increase their risk of unplanned hospitalizations.

The results of this study have identified important questions and observations about the administration of OPAT. First, the location of OPAT receipt impacts the risk of unplanned hospitalizations for patients receiving long-term parenteral antibiotics. Delivery of OPAT at a skilled nursing facility, even in an adjusted model, leads to a higher rate of hospitalization, and there appears to be specific risk related to AKI. Second, an evidence-based clinical decision support tool that involves evaluation of comorbidities, such as Charlson comorbidity index score, could be useful to guide the selection of patients who receive OPAT and better assess risk to help determine the most appropriate venue to improve patient outcomes and reduce unplanned hospitalizations. A prospective study to evaluate different management strategies for the delivery of OPAT dependent upon the venue may help answer pressing questions surrounding optimal management of OPAT patients to reduce unplanned hospitalizations.

OPAT is a viable alternative to delivery of longer-term intravenous antimicrobials in the acute-care setting, and the prescription of OPAT continues to increase as our healthcare system looks for alternatives to the expense of inpatient treatment. However, treatment with antimicrobials for ongoing infection in the outpatient setting does have potential complications, and prior literature has shown this population discharged on OPAT is at increased risk of unplanned hospitalizations. This study is the first step toward elucidating specific risk factors associated with unplanned hospitalizations related to the site of therapy delivery and patient demographics that may inform future interventions in this select population and allow a more individualized and successful approach to OPAT in our patients.

Supplementary Data

Supplementary materials are available at *Open Forum Infectious Diseases* online. Consisting of data provided by the authors to benefit the reader, the posted materials are not copyedited and are the sole responsibility of the authors, so questions or comments should be addressed to the corresponding author.

Acknowledgment

Potential conflicts of interest. All authors: No reported conflicts of interest. All authors have submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest. Conflicts that the editors consider relevant to the content of the manuscript have been disclosed.

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