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Outpatient Parenteral Therapy for Complicated *Staphylococcus aureus* Infections: A Snapshot of Processes and Outcomes in the Real World

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Background. In the United States, patients discharged on outpatient parenteral antimicrobial therapy (OPAT) are often treated by home health companies (HHCs) or skilled nursing facilities (SNFs). Little is known about differences in processes and outcomes between these sites of care.

Methods. We performed a retrospective study of 107 patients with complicated *Staphylococcus aureus* infections discharged on OPAT from 2 academic medical centers. Clinical characteristics, site of posthospital care, process measures (lab test monitoring, clinic follow-up), adverse events (adverse drug events, *Clostridium difficile* infection, line events), and clinical outcomes at 90 days (cure, relapse, hospital readmission) were collected. Comparisons between HHCs and SNFs were conducted.

Results. Overall, 33% of patients experienced an adverse event during OPAT, and 64% were readmitted at 90 days. Labs were received for 44% of patients in SNFs and 56% of patients in HHCs. At 90 days after discharge, a higher proportion of patients discharged to an SNF were lost to follow-up (17% vs 3%; *P* = .03) and had line-related adverse events (18% vs 2%; *P* < .01). Patients discharged to both sites of care experienced similar clinical outcomes, with favorable outcomes occurring in 61% of SNF patients and 70% of HHC patients at 90 days. There were no differences in rates of relapse, readmission, or mortality.

Conclusions. Patients discharged to SNFs may be at higher risk for line events than patients discharged to HHCs. Efforts should be made to strengthen basic OPAT processes, such as lab monitoring and clinic follow-up, at both sites of care.

Keywords. hospital readmissions; infectious disease; OPAT, *Staphylococcus aureus*.

Outpatient parenteral antimicrobial therapy (OPAT) is the standard of care for patients requiring long-term parenteral antimicrobials and is utilized to facilitate early hospital discharge for patients with infections [1]. These programs are patient-centric, cost-effective [2–4], and safe [5] alternatives to inpatient hospitalization for intravenous (IV) antimicrobial treatment. In the United States, OPAT is administered in a variety of settings including via home health companies (HHCs) and skilled nursing facilities (SNFs).

Despite broad acceptance of OPAT programs in the United States, little is known about patient- and program-level outcomes. Reports of processes and outcomes of OPAT care

have been limited to single-center studies [6–9], with few studies explicitly comparing outcomes in SNFs vs HHCs. For example, an analysis of OPAT processes from the University of Pennsylvania found that HHC patients were more likely than SNF patients to have labs seen by an infectious diseases (ID) professional within 1 week of discharge (odds ratio [OR], 2.35; 95% confidence interval [CI], 1.51–3.65) and to attend follow-up appointments (OR, 2.57; 95% CI, 1.56–3.89). In terms of outcomes, HHC patients were less likely to have an adverse drug event (OR, 0.52, 95% CI, 0.29–0.91) and a relapse or clinical failure compared with SNF patients (OR, 0.49, 95% CI, 0.27–0.89) [6].

Bhavan et al. described the outcomes of the OPAT program at a safety net hospital, Parkland Hospital in Dallas, Texas, comparing the results of uninsured patients discharged to home to self-administer antimicrobials (s-OPAT) with the more traditional cohort of patients with insurance discharged to SNFs and HHCs (H-OPAT). The 30-day readmission rate in the H-OPAT group was 21%, compared with 16.7% in the S-OPAT group. The authors only provided a combined outcome and did not differentiate between those linked to SNFs vs HHCs. For patients and insurers to make more informed decisions about posthospital

OPAT care, more evidence is needed that compares outcomes for these varied sites of care.

We addressed this data gap among a cohort of patients with complicated *Staphylococcus aureus* (SA) infections from 2 academic medical centers in our system. Given the virulence of SA and the toxicity of firstline antimicrobials (oxacillin [10] and vancomycin [11]), patients receiving these agents require close follow-up to prevent both adverse drug events and relapsing infection [12, 13]. We presumed that by following the longitudinal OPAT course of this group, we could observe our OPAT program "at its best." The objectives of our study were to (1) characterize current OPAT processes and outcomes for complicated SA cases and (2) compare OPAT processes and outcomes among patients receiving antimicrobials in HHCs vs SNFs.

METHODS

Hospitals and Setting
Johns Hopkins Bayview Medical Center (BMC), a 440-bed academic tertiary care center, and the Johns Hopkins Hospital (JHH), a 1194-bed academic quaternary care center, serve Baltimore, Maryland, and the surrounding area. Both acute care hospitals have access to inpatient and outpatient infectious diseases consult services.

OPAT Program Description
Before the study period (1/2013–12/2014), there was no systematic OPAT data collection. Beginning in 2013, hospital case managers referred some, but not all, adult OPAT patients to the outpatient ID clinic at the time of discharge. ID consultation was not mandatory before discharge, and all OPAT orders were placed by the discharging provider, who had no role in following the patient in the outpatient setting. In general, these patients were seen in the ID clinic for routine visits between 1 week and 3 weeks after discharge. A small percentage of skilled nursing facilities (~5%) in our area contract with ID physicians to manage patients on long-term antibiotics, but our ID division was not routinely notified about the findings of these rounds. Outpatient antibiotics were administered by a variety of HHCs and SNFs depending on patient insurance contracts and medical needs. Between visits at BMC, a nurse practitioner called SNFs and HHCs for missing results. At JHH, medical office coordinators placed calls at provider request. The BMC ID nurse practitioner was the only resource dedicated to the OPAT program.

Patient Selection and Data Collection
We identified complicated SA cases discharged on OPAT from our health system. First, between January 2013 and December 2014, patients who grew SA from a sterile source during an inpatient admission were identified from microbiology laboratory data. To generate a feasible number of records for manual data extraction, every second patient encounter was selected for manual chart review. Based on medical record review, patients with a complicated infection during their hospital stay were

included. Complicated infections were defined as infections of bone and joint (osteomyelitis, septic arthritis, prosthetic joint infections, vertebral osteomyelitis, or discitis), central nervous system (cranioplasty site infections, ventricular shunt infections, meningitis, or spinal epidural abscess), and endovascular sources (catheter-associated bloodstream infections, endocarditis, vascular graft infections, or septic thrombophlebitis) requiring more than 2 weeks of IV therapy. Skin and soft tissue infections, intra-abdominal infections, and pneumonia were excluded. Patients who elected to be followed by physicians outside of our health system were excluded as records were not routinely available for review.

Clinical characteristics were recorded on a standardized case review form, including demographic information, clinical outcomes, adverse events related to medications or vascular access, and readmissions at 30 and 90 days after the initial index discharge. Clinical data were extracted via manual review of the electronic medical record (EMR) and from the institutional data warehouse (PREMIER QualityAdvisor Database, Premier Inc., Charlotte, NC) using patient-level queries of billing data and administrative codes (International Classification of Diseases, 9th Revision) (Supplementary Table 1). To validate the data abstraction, 12 charts (11%) were randomly selected and reviewed by an external reviewer. The interrater reliability was 0.97 (κ, 0.97; 95% confidence interval [CI], 0.93–1.0).

Outcome Definitions
The primary outcome was treatment outcome at 90 days. A favorable outcome ("cure") was defined as a patient who was clinically improved and without evidence of infection, without antimicrobials or on suppressive oral antimicrobials in the setting of retained hardware or a nonremovable source. An unfavorable outcome ("treatment failure") was defined as a patient who did not meet the above criteria for cure, was lost to follow-up, had a relapse, or was placed in hospice. Relapse was defined as any of the following after a period of clinical improvement and hospital discharge: isolation of SA with the same susceptibility pattern as the index episode from the blood or other sterile clinical specimen, recurrence of previous symptoms, radiographic evidence of worsening at the site of the previous source requiring additional antimicrobial therapy, change in antimicrobial therapy due to progression of infection (not due to adverse drug event), additional surgical or radiologic procedure for control of infection, or other source control intervention. If a patient relapsed any time before 90 days, treatment was modified, and they improved again before the end of 90 days, he or she was still considered a relapse for the purposes of our analysis.

Secondary outcomes included adverse events associated with IV catheters or medications, 30- and 90-day readmission, and death during the follow-up period.

Encounters with an ID provider were documented as ID follow-up. Patients were considered lost to follow-up if they

did not have any encounters with a provider addressing their infection or antibiotic course at or after the specified follow-up time point.

Adverse events (AEs) included adverse drug events (ADEs) and were defined as unfavorable and unintended signs, laboratory findings, or symptoms temporally associated with and thought by the treatment team to be a consequence of an antimicrobial or device. This included *Clostridium difficile* colitis with onset after discharge. Catheter complications included (1) catheter infection, defined as a laboratory-confirmed bloodstream infection in a patient with a central catheter, or an IV catheter site infection surrounding the catheter insertion site [14], or clinical sepsis that resolved after line removal; or (2) noninfectious line events such as external leakage, extravasation, or catheter-associated venous thromboembolism, or if the line became dislodged or accidentally removed, necessitating line replacement [15]. AEs were noted by reviewing clinical documentation after hospital discharge.

In the case of ADEs, if patients received multiple medications throughout their course, the culprit medication was determined based on the timing of administration (medications given after the reaction were ignored) and the frequency of adverse events listed in drug monographs Wolters Kluwer Clinical Drug Information, Inc. (Lexi-Drugs). Wolters Kluwer Clinical Drug Information, Inc.; April 15, 2013.

Comorbidities and Process Definitions

Immunocompromised patients were defined as those having the following conditions during hospital admission: uncontrolled diabetes with a hemoglobin A1c >8, use of prednisone (14 days of 10 mg/d or greater), or immunosuppressants or chemotherapy within the preceding 6 months (ie, tumor necrosis factor inhibitors, calcineurin inhibitors), AIDS with a CD4 <250, presence of solid organ or bone marrow transplant, or neutropenia (absolute neutrophil count < 1000 cells/μL for ≥7 days).

The 3M All-Patient Refined Diagnosis-Related Groups (APR-DRG) severity subclass is a calculated measure of the extent of physiologic decompensation or organ system loss of function and is used to measure the complexity of a hospital's patient case mix [16]. The metric considers the patient's multiple comorbidities and any complications of the index hospitalization and is useful for predicting readmissions [17]. A severity score (1 = minor severity, 2 = moderate, 3 = severe, 4 = extreme) was assigned for each patient at the time of discharge using a proprietary algorithm and was extracted from the institutional Electronic Data Warehouse (EDW)..

Source control was defined as a procedure or intervention to drain, debulk, or remove the source of infection. Examples included removal of infected catheters, incision and drainage of abscesses, and revision of a prosthetic joint. Patients were not required to have full hardware removal to meet criteria for source control if the infected site was washed or drained in an attempt to remove as much infection as possible.

We defined patient noncompliance as clinician documentation of patient refusal of recommended source control procedure during hospital admission, refusal of antimicrobials during admission or follow-up, not presenting to any clinic visits 30 days after discharge, refusing lab draws or home nursing services, or leaving a skilled nursing facility against medical advice.

Laboratory tests were obtained weekly, as is recommended by national guidelines [18]. For instance, if a patient was on parenteral therapy for 17 days, we defined this individual as having 2 patient-weeks, or 2 lab opportunities. If the clinic received any requested labs (including incomplete sets of labs) during an OPAT patient-week, this was counted as lab completion for that patient-week.

Statistical Analysis

Demographic and clinical features of OPAT patients with complicated SA infections discharged to SNFs were compared with those discharged to HHCs using Student *t* tests with unequal variances and chi-square or Fisher exact tests for continuous and categorical variables, respectively. OPAT processes and outcomes were then compared between groups in a similar manner. Finally, we examined individual-level characteristics and their association with unfavorable outcomes at 90 days using logistic regression. Gender and APRDRG were the only 2 variables that were statistically significantly associated with 90-day outcomes in these exploratory analyses; a multivariable logistic regression was then used to evaluate the direction and magnitude of these associations following adjustment for discharge site, age, mental illness, and type of infection (methicillin-resistant SA [MRSA] or methicillin-sensitive SA [MSSA]). The results of these models are presented as odds ratios with corresponding 95% confidence intervals. A *P* value <.05 was considered statistically significant. All analyses were performed using STATA, version 14.1 (College Station, TX, USA).

RESULTS

Patient Selection

Overall, we identified 553 patients with cultures growing SA from sterile sites between January 2013 and December 2014. Of the 281 medical records reviewed, 174 patients were excluded. Those excluded had uncomplicated infections (n = 55), were not discharged on IV antimicrobials (n = 89), SA was not the primary pathogen (n = 22), or there were no outcomes data (n = 1). Among the 107 eligible patients comprising the study population, 62% (n = 66) were discharged to an HHC and 38% (n = 41) were discharged to an SNF.

Patient Demographics and Clinical Characteristics

Demographic and clinical characteristics were similar in both SNF and HHC groups. A majority of patients were male (57%), and Medicare was the most common insurance type in

Table 1.   Clinical Features of Patients With Complicated Staphylococcal Infections Discharged on OPAT Between 1/2013 and 12/2014, Comparing Patients Discharged to Skilled Nursing Facilities vs Home Health

	Overall		Skilled Nursing Facility		Home Health		
	No.	%	No.	%	No.	%	P Value
	(n = 107)	100	(n = 41)	38.3	(n = 66)	61.6	
Social and demographic features							
Male gender	61	57.0	21	52.5	40	60.6	.54
Mean age, y	54.1	17.3	58.4	16.3	51.3	17.6	.04
Race							
White	71	66.4	31	75.0	40	60.6	-
Black	30	28.0	8	20.0	22	33.3	-
Unavailable	5	4.7	2	5.0	3	4.5	-
Asian	1	0.9	0	0.0	1	1.5	.38
Insurance							
Medicare	48	44.9	23	55.0	25	37.9	.14
Commercial insurance	29	27.1	7	17.5	22	33.3	-
Medicaid	25	23.4	8	20.0	17	25.8	-
Self-pay	5	4.7	3	7.5	2	3.0	-
Social support							
Lives with others	74	69.2	26	62.5	48	72.7	-
Lives alone, has support	20	18.7	6	15.0	14	21.2	-
Unknown	9	8.4	5	12.5	4	6.1	-
Lives alone, no support	4	3.7	4	10.0	0	0.0	.04
History of intravenous drug abuse	7	6.5	4	10.0	3	4.5	.42
Hospitalized in past 3 mo	57	53.3	26	65.0	30	45.5	.08
Comorbid conditions at hospital discharge							
APRDRG severity subclass							
1	1	0.9	0	0.0	1	1.5	.30
2	25	23.4	7	17.5	18	27.3	-
3	38	35.5	13	32.5	25	37.9	-
4	43	40.2	21	50.0	22	33.3	-
Wound care needs	39	36.4	12	30.0	26	39.4	.44
Severe neurologic compromise	37	34.6	18	45.0	18	27.3	.10
Immunocompromise	31	29.0	10	25.0	21	31.8	.60
Mental illness or psychiatric disturbance	25	23.4	13	32.5	12	18.2	.15
Major fracture or amputation	7	6.5	5	12.5	2	3.0	.10
Characteristics of infection							
Site of infection							
Musculoskeletal	58	54.2	26	63.4	32	48.5	.16
Endovascular	40	37.4	13	31.7	27	40.9	.41
Central nervous system	9	8.4	2	4.9	7	10.6	.47
Bacteremia present	69	64.5	30	73.2	39	59.1	.24
Prosthetic material infected	51	47.7	22	53.7	29	43.9	.51
Microorganism							
MSSA	58	54.2	19	46.34	39	59.1	.23
MRSA	52	48.6	22	55.0	30	45.5	.45
Polymicrobial	29	27.6	11	27.5	18	28.1	1.00
Antibiotic at discharge							
Vancomycin	49	45.8	21	52.5	28	42.4	.42
Oxacillin	42	39.3	16	40.0	26	39.4	1.00
Cefazolin	13	12.1	4	9.8	9	13.6	.53
Daptomycin	3	2.8	0	0.0	3	4.5	.29
Ceftriaxone	2	1.9	0	0.0	2	3.0	.53
Intravenous access at discharge							
Peripherally inserted central catheter	82	76.6	30	75.0	52	78.8	-
Tunneled central line	22	20.6	10	24.4	12	18.2	.89
Mediport	2	1.9	1	2.5	1	1.5	-
Fistula	1	0.9	0	0.0	1	1.5	-

Abbreviations: APRDRG, All-Patient Refined Diagnosis-Related Group; MRSA, methicillin-resistant *Staphylococcus aureus*; MSSA, methicillin-sensitive *Staphylococcus aureus*; OPAT, outpatient parenteral antibiotic therapy.

both groups (45%). Patients treated by HHCs were younger (51 years vs 58 years; $P = .04$) (Table 1). A majority of patients had been hospitalized within 3 months before the index admission (53%). Vancomycin, followed by oxacillin, was the most common antimicrobial used after discharge (46% and 39%, respectively). Most of the patients who required source control underwent appropriate procedures (n = 87, 92%) during hospital admission.

OPAT Processes

The OPAT processes at our institutions were similar in both groups (Table 2). Most patients (87%) were seen by an ID consultant before discharge, but only 55% of people were seen in the ID clinic after discharge. At least 1 laboratory study was obtained in 51% of OPAT patients. When considering all weekly labs, the OPAT practitioners received 109 partial or complete sets of labs for 485 weeks of OPAT (22%).

Many of the OPAT processes of care were similar between patients in SNFs or with HHCs (Table 2). The ID clinic received results from 44% of SNF patients and 56% of HHC patients ($P = .25$). At the 90-day follow-up, the proportion of patients retained in care within our health system (any provider) was significantly higher among patients discharged to HHCs than for SNFs (97% vs 83%, respectively; $P = .05$). A significantly greater proportion of line-related AEs occurred in the SNF group vs the HHC group (18% vs 2%; $P < .01$).

OPAT Outcomes

In total, 35 patients (33%) suffered 37 AEs, and 17 were readmitted (Table 3). A majority of events were ADEs (n = 26, 70%), line complications (n = 8, 22%), and several were due to *Clostridium difficile* (n = 3, 8%). Sixteen of the 26 ADEs (62%) resulted in a change of therapy or premature termination of treatment. ADEs

occurred in 20% (n = 10/49) of vancomycin courses, 24% of oxacillin (n = 10/42), and 15% of cefazolin (n = 2/13).

At the time of completion of IV antimicrobials, 86% of patients had a favorable outcome. This decreased to 71% at 90 days after discharge due to a relapse rate of 22%. All-cause 30-day and 90-day readmission rates were high (34% and 64%, respectively). In our sample, 53% of 90-day readmissions were related to the OPAT-related complications.

Patients discharged to both sites of care experienced similar clinical outcomes, with favorable outcomes occurring in 61% of SNF patients and 70% of HHC patients at 90 days. There were no differences in rates of relapse, readmission, or mortality.

Variables Associated With Unfavorable Outcomes at 90 Days

To determine factors associated with poor outcomes, a multivariable logistic regression adjusted for sex, mental illness, APRDRG severity subclass, MRSA, presence of bacteremia, and site of care determined that males had better outcomes at 90 days (OR, 0.23; 95% CI, 0.07–0.73) and those with higher APR-DRG severity (4) had a 5-fold higher risk of an unfavorable outcome (OR, 5.36; 95% CI, 1.27–22.74) (Table 3). The magnitude and precision of these estimates were similar to univariate associations (results not presented).

DISCUSSION

OPAT is a critical component of care as patients transition from hospitals; however, the impact has been poorly studied. In this study, we identified a number of deficiencies in OPAT care processes that present significant threats to patient safety. A third of patients treated at both SNFs and HCCs experienced (37% in SNFs and 35% with HHCs) AEs. Neither SNFs nor HHCs reported weekly laboratory data in a reliable and consistent manner. Half of patients did not have follow-up laboratory

Table 2. OPAT Process Measures for Patients With Complicated Staphylococcal Infections Discharged on OPAT Between 1/2013 and 12/2014, Comparing Patients Discharged to Skilled Nursing Facilities vs Home Health

	Overall		Skilled Nursing Facility		Home Health		
	No.		No.		No.		
	(n = 107)	%	(n = 41)	%	(n = 66)	%	*P* Value
Process measures							
Hospital management							
Source control indicated	95	88.8	35	87.5	59	89.4	.76
Source control done (if indicated)	87	81.3	34	82.9	52	78.8	.78
Prosthetic material removed (if present)	32	29.9	16	39.0	16	24.2	.16
ID consult before discharge	93	86.9	39	95.1	54	81.8	.07
ID follow-up arranged	67	62.6	27	65.9	40	60.6	.81
Postdischarge management							
Duration of OPAT (average, range)	31.75	(6–130)	31.80	(9–130)	31.71	(6–72)	.19
Seen in ID clinic in follow up while on IV therapy	59	55.0	26	63.4	33	50.0	.23
Labs received by ID	55	51.4	18	43.9	37	56.1	.25
No. of ID visits while on IV therapy, median (IQR)	2	1.0	1	(1–2)	2	(1–2)	.07
Patient noncompliance	13	12.1	5	12.2	8	12.1	1.00

Abbreviations: ID, infectious diseases; IQR, interquartile range; IV, intravenous; OPAT, outpatient parenteral antibiotic therapy.

Table 3. OPAT Outcomes and Predictors of Unfavorable Outcomes at 90 Days for OPAT Patients

	Overall		Skilled Nursing Facility		Home Health		
	No.		No.		No.		
	(n = 107)	%	(n = 41)	%	(n = 66)	%	P Value
OPAT-related adverse events (90 d postdischarge)	37	34.6	15	36.6	23	34.8	.99
Total patients with adverse events	35	32.7	12	29.3	23	34.8	.70
Readmission for adverse event	17	15.9	5	12.2	12	18.2	.58
Type of adverse event							
Adverse drug events	26	24.3	7	17.1	19	28.8	.25
Therapy modified or discontinued for ADE	16	15.0	7	17.1	9	13.6	.84
Line related	8	7.5	7	17.1	1	1.5	.01
Line infection	8	7.5	6	14.6	2	3.0	.05
Noninfectious line complication	1	0.9	1	2.4	0	0.0	-
Clostridium difficile infection	3	2.8	1	2.4	2	3.0	.80
Treatment outcomes							
At end of OPAT therapy							
Favorable	86	80.4	31	75.6	55	83.3	.47
Cure	68	63.6	26	63.4	42	63.6	.99
Suppression	18	16.8	5	12.2	13	19.7	.46
Unfavorable	14	13.1	5	12.2	9	13.6	.99
At 90 d postdischarge							
Favorable	71	66.4	25	61.0	46	69.7	.47
Cure	56	52.3	21	51.2	35	53.0	.99
Suppression	15	14.0	4	9.8	11	16.7	.47
Unfavorable	20	18.7	9	22.0	11	16.7	.67
Lost to follow-up	9	8.4	7	17.1	2	3.0	.03
Relapse	22	20.6	6	14.6	15	22.7	.44
Death	6	5.6	2	4.9	4	6.1	.99
Readmission rates							
30-d readmissions	34	31.8	12	29.3	22	33.3	.82
90-d readmissions	64	59.8	21	51.2	43	65.2	.22
OPAT-related 90-d readmissions	34	31.8	13	31.7	21	31.8	.99
Worsening or relapsing infection	17	15.9	7	17.1	10	15.2	.99
Adverse drug event	8	7.5	1	2.4	7	10.6	.15
Line complication	6	5.6	4	9.8	2	3.0	.20
Sequelae of original infection	2	1.9	1	2.4	1	1.5	.99
Planned surgery	1	0.9	0	0.0	1	1.5	-
OPAT-unrelated readmissions	30	28.0	8	19.5	22	33.3	.18
Multivariable model of predictors of unfavorable outcome at 90 days. Model is adjusted for the variables listed.							

Variable	Adjusted Odds Ratios	95% CI	P Value				
Male gender	0.23	(0.07–0.73)	.013				
Age	1.00	(0.97–1.03)	.955				
Mental illness	2.22	(0.71–6.96)	.173				
APRDRG severity subclass (compared with 2)							
3	1.28	(0.27–6.10)	.759				
4	5.36	(1.27–22.74)	.023				
MSRA vs MSSA	1.22	(0.43–3.47)	.708				
Treating facility (SNF vs HHC)	0.66	(0.22–1.98)	.459				

Abbreviations: ADE, adverse drug event; APRDRG, All-Patient Refined Diagnosis-Related Group; CI, confidence interval; HHC, home health company; MRSA, methicillin-resistant *Staphylococcus aureus*; MSSA, methicillin-sensitive *Staphylococcus aureus*; OPAT, outpatient parenteral antibiotic therapy; SNF, skilled nursing facility.

testing in accordance with national guidelines. This is comparable to what other programs have found. One previous study of OPAT processes found that only 37% of laboratory tests were reviewed by an infectious diseases specialist 1 week after hospital discharge [6]. In that study, using a structured team to pursue missing laboratory data increased compliance to 94%. In the era of electronic medical records, phone calls and facsimiles of results may soon be obsolete. However, the transition to

electronic data transfer has been hampered by the cost and burdens of electronic data-sharing agreements. These barriers have prevented the implementation of automatic lab transmission to date and negatively impact patient safety. In a large academic medical center report of OPAT outcomes, the lack of availability of recommended laboratory test results was associated with increased readmissions (adjusted OR, 2.53; 95% CI, 1.36–4.73), though causality cannot be confirmed [9].

Second, patients treated at both sites of care experienced high rates of OPAT-related AEs (37% in SNFs and 35% with HHCs). The proportion of patients experiencing a therapy modification for an ADE (15%) is higher than what was reported in the OPAT Outcomes Registry (4.6% of courses stopped early for ADE) [2]. The high ADE rate in this study may be related to inconsistent laboratory testing and follow-up, leading to delayed recognition of drug toxicity, or simply due to a broader definition of ADE than was used in the registry. Commonly used antimicrobials for SA infections (vancomycin for MRSA and oxacillin for MSSA) are associated with significant side effects in the OPAT population [11, 19–23]. The case for OPAT monitoring as a patient safety imperative should be articulated to policy-makers and hospital administrators alike, emphasizing that investments in these processes may reduce overall costs to the health care system via decreased complications and readmissions [6, 9, 24].

Third, the high readmission rates at both time points studied, 30 and 90 days after discharge, further underscore the challenges with treating SA infections. In this era of value-based care, hospitals have strong incentives to reduce readmissions to avoid penalties from payors [25]. In a well-established OPAT program such as the one at Parkland Hospital in Dallas, Texas, which has a strong multidisciplinary tracking system in place, the 30-day readmission and relapse rates for SA infections (including uncomplicated cases) were much lower than in our cohort (20% and 2%, respectively) [13]. Data from previous studies have demonstrated that intentional investments into OPAT staffing and infrastructure can result in substantial improvements in patient outcomes [6, 26–28].

Whether OPAT is provided in an SNF or by HCC, our results demonstrate that care processes need to be strengthened to improve patient safety and adhere to standards of care put forth by national guidelines [18]. In neither setting were laboratory results transmitted to our ID providers or clinic per national recommendations. Furthermore, our findings suggested that patients managed in SNFs were at increased risk of AEs. They were much more likely to have line-related events. As neither SNFs nor HHCs are currently required to report infection rates to regulators or the National Health Surveillance Network, they cannot be compared, and care providers may be unaware of the risks. This finding also aligns with national surveillance reports of high rates of line-associated bloodstream infections in long-term acute care facilities [29]. Challenges of infection control and prevention in long-term care facilities are long-standing and well known [30–32]. Second, patients in SNFs were lost to follow-up more frequently, making it difficult for our program to track and report their outcomes. In reality, the rates of adverse events or unfavorable outcomes may have been even higher than measured in our sample. We investigated whether this poor clinic follow-up was due to patient insurance network restrictions. In a review of 3 months of recent data, we found that 7 of 85 patients (8.2%) had insurance that was not accepted by our ID clinic. If all these patients had been scheduled and kept their appointments, this would have put the follow-up rate at 63%, which is still well below recommended benchmarks.

To overcome the barriers in result transmission and clinical communication, our program is planning to pilot a telemedicine approach with 2 local nursing facilities. The planned workflow is to engage a nursing home provider in a virtual rounding process in which the results and clinical course of OPAT patients are presented and discussed telephonically. The hope is that this process will decrease the amount of time our program staff spend obtaining results and clinical information from these facilities, and potentially avoid transporting well patients back and forth to clinic when no changes to management are necessary.

Our study has several limitations. First, the relatively small sample size precluded a more rigorous analysis of risk factors or predictors of poor outcomes between OPAT settings. This further limited our ability to delve into other factors that contribute to favorable outcomes after discharge to either an SNF or HHC. Although our study population was drawn from 2 participating institutions, it is possible that there are differences in the composition of the sample and the actual population. Second, although our sample was drawn from patients at 2 hospitals, the programs were in the same city and were highly intertwined in terms of processes and resources; therefore, our findings may not be generalizable to other OPAT programs or institutions. Third, the higher observed rate of ADEs among HHC patients may partially be explained by differentially higher rates of lab availability in HHCs compared with SNFs. The higher rate of lab collection and transmission to ID providers may have contributed to ADEs being detected more frequently. Also, as a greater proportion of patients in the SNF population were lost to follow-up, ADEs may have occurred at the same rate as HHCs, but patients never returned to clinic to report them.

A further limitation of our study is that our data search was limited to our health system EMRs. We cannot determine from our data if the defect in laboratory test performance is at the level of the SNF or HHC performing the labs, or at the level of result transmission to our care team. Universally, patients at SNFs are seen by in-house providers (occasionally ID physicians) who review results and often modify treatment courses or prescribe new antibiotics. Treatment changes usually come to the attention of the hospital ID team if patients return to clinic or are readmitted to the hospital. Our OPAT team is undertaking efforts to establish clear communication expectations, protocols, and

telemedicine strategies between SNFs and our ID department so that we may be notified earlier of potential adverse events.

Despite clear guidelines for best practices in OPAT, rates of adherence to these practices were low in our population of complicated staphylococcal infections. High AE rates, readmission rates, and relapse rates occurred in our patient sample irrespective of the site of OPAT administration. Site-specific strategies for empowering OPAT programs to adhere to guidelines would likely improve outcomes. Further studies with a larger patient population such as a revitalized national registry are sorely needed to gather outcomes data and drive policies to support best practice and safer care for this population.

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.

Acknowledgments

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