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Concise Communication

Trends in intravenous antimicrobial start rates in outpatient hemodialysis centers, United States, 2012–2021

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Abstract

Using National Healthcare Safety Network data, an interrupted time series of intravenous antimicrobial starts (IVAS) among hemodialysis patients was performed. Annual adjusted rates decreased by 6.64% (January 2012–March 2020) and then further decreased by 8.91% until December 2021. IVAS incidence trends have decreased since 2012, including during the early COVID-19 pandemic.

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Introduction

Nearly 1 in 3 persons on maintenance hemodialysis receives intravenous antimicrobials annually, and among those administered, up to 50% may not be clinically indicated.[1] During the early COVID-19 pandemic, antibiotic use rates increased in US hospitals,[2] raising concern that similar effects would occur in other healthcare settings like dialysis clinics. A previous analysis of National Healthcare Safety Network (NHSN) data found that pooled annual rates of intravenous antimicrobial starts (IVAS) reported from 2016 to 2020 in outpatient hemodialysis clinics decreased.[3] However, this analysis did not account for granular trends in antibiotic prescribing or effects from the early COVID-19 pandemic.

To further characterize outpatient IVAS among persons receiving outpatient hemodialysis, we analyzed trends of IVAS rates reported to NHSN from 2012 to 2021, controlling for seasonal patterns, facility characteristics, and the COVID-19 pandemic.

Methods

NHSN is a US surveillance system that tracks healthcare-associated infections across ≥38,000 facilities. Since January 2012, outpatient hemodialysis facilities follow a protocol and report monthly data to participate in the End Stage Renal Disease Quality Incentive Program, a value-based purchasing program administered by the Centers for Medicare and Medicaid Services.[4] Facilities submit an annual Facility Practices Survey, a monthly Facility Census Form, which records the number of patients on the first 2 workdays of the month and provides patient-months for point incidence rate calculations, and a monthly Dialysis Event Form. There are 3 reportable dialysis events: an IVAS, a positive blood culture bloodstream infection (BSI), and a pus, redness, or swelling event at the vascular access site.

IVAS data reported to NHSN during 2012–2021 were analyzed. To be considered a new IVAS event, at least 21 days had to elapse following another IVAS event. Events were excluded if they were duplicative, violated the 21-day rule, did not have a vascular access type specified, or were from a facility reporting missing or zero patient-months for that month. IVAS events and the monthly number of dialysis patients for each facility were summarized by vascular access type according to infection risk (central venous catheters (CVC), other (eg, catheter-graft hybrids), arteriovenous grafts (AVG), and arteriovenous fistula (AVF) access) to calculate crude incidence rates.

An interrupted time series with mixed effects negative binomial regression modeled the trend of IVAS rates associated with the early COVID-19 pandemic, March 2020–December 2021. The dependent variable was monthly IVAS events at each facility, offset by the natural logarithm of the facility patient-months. The independent variables were a linear term for months, a binary indicator variable for before and after March 2020, and an interaction term between these 2 variables, which allowed an estimate of any level change of IVAS rates in March 2020. Other covariates included were vascular access type, seasonality (expressed as sine (sin(2*π*month/12)) and cosine (cos(2*π*month/12)) to

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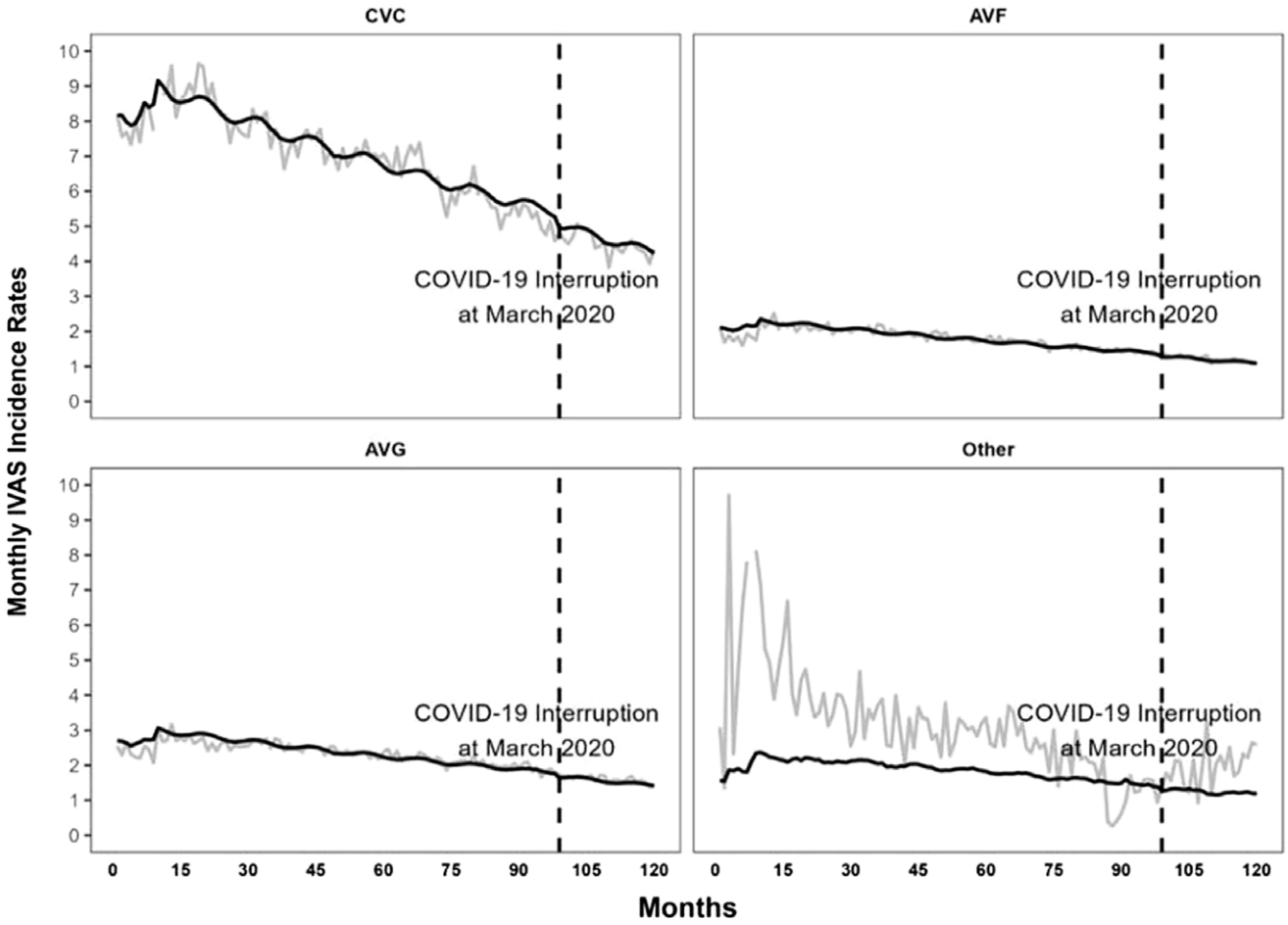

Figure 1. Monthly crude and predicted intravenous antimicrobial starts (IVAS) per 100 patient-months by vascular access type, National Healthcare Safety Network, 2012–2021. CVC, central venous catheter; AVF, arteriovenous fistula; AVG, arteriovenous graft.

predict yearly incidence peak and nadir[5]) and facility characteristics, including station number in quartiles, belonging to a dialysis organization, and hospital affiliation. A sensitivity analysis was conducted for facilities reporting to NHSN for at least 6 continuous months per year from 2012 to 2021. Analyses were performed using SAS software (version 9.4; SAS Institute).

Results

The number of outpatient hemodialysis facilities reporting to NHSN increased from 5,581 in 2012 to 7,313 in 2021. Facility characteristics remained constant throughout the study: approximately 87.39% were not associated with a hospital, and 88.70% were part of a dialysis organization. The median number of dialysis stations was 17 (interquartile range: 12, 24).

Crude IVAS rates decreased annually from 2012 to 2021. Patients with CVC, other, AVG, and AVF access had IVAS rates of 8.86, 6.03, 2.70, and 2.12 events per 100 patient-months in 2012, which decreased to 4.31, 2.19, 1.55, and 1.16 events per 100 patient-months, respectively, in 2021 (Figure 1). Between 2012 and February 2020, the pooled crude IVAS rate was 2.90 events per 100 patient-months (1,060,504/36,613,799), which was 6.92, 2.96, 2.33, and 1.80 events per 100 patient-months, respectively, when stratified by CVC, other, AVG, and AVF access. During the early COVID-19 period, the pooled crude IVAS rate was 2.07 events per 100 patient-months (195,717/9,455,621) and 4.49, 1.96, 1.61, and 1.22 events per 100 patient-months when stratified by vascular access route.

Adjusted IVAS rates decreased by an average of 6.64% each year (95% CI, 6.56%–6.73%) from January 2012 to February 2020 (Table 1). In March 2020, there was a 5.85% drop (95% CI, 4.85%–6.84%) in average annual IVAS rates. During the early COVID-19 period, the trend of decreasing annual IVAS rates was sustained at 8.91% (95% CI, 8.10%–9.74%).

Patients with CVC and AVG were 3.99 (95% CI, 3.97%–4.01%) and 1.30 (95% CI, 1.29%–1.31%), respectively, times as likely to have an IVAS compared with patients with AVF access. Facilities with 25 or more stations were 1.05 (95% CI, 1.03%–1.07%) times as likely to have an IVAS compared with facilities with 17 or fewer stations. Annual IVAS rates peaked in August and reached their nadir in February.

Among 5,244 (71.7%) facilities reporting continuously, adjusted IVAS rates decreased by 6.57% (95% CI, 6.47%–6.66%) annually from 2013 to 2021. There was a discrete drop of 6.15% (95% CI, 5.06%–7.23%) in IVAS rates in March 2020. The IVAS rates decreased by 8.72% (95% CI, 7.8%–9.62%) annually during the early COVID-19 period.

Discussion

This report uses national surveillance data to demonstrate a decreasing trend in annual IVAS incidence from 2012 to 2021. The

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Table 1. Intravenous antimicrobial starts interrupted time series model with estimated adjusted incidence rate ratios (aRR) and annual percent change, National Healthcare Safety Network, 2012–2021

Model parameter[a]	Parameter estimates at monthly level	Yearly aRR (95% CI)	Percent change per year[b] (95% CI)	*P*-value
Time trend before COVID-19, Jan 2012–Feb 2020 (β1)[c]	−0.006	0.934 (0.933, 0.934)	−6.645 (−6.735, -6.555)	<0.001
Change in slope during COVID-19, Mar 2020–Dec 2021 (β2)[c]	−0.002	0.976 (0.967, 0.985)	−2.430 (−3.316, −1.548)	<0.001
Time trend during COVID-19, Mar 2020–Dec 2021 (β1+ β2)[c]	−0.008	0.911 (0.903, 0.919)	−8.913 (−9.745, −8.097)	<0.001
	Parameter estimates	**aRR (95% CI)**	**Percent change[b]**	***P*-value**
Level change of COVID-19 interruption in March 2020	−0.060	0.941 (0.932, 0.951)	−5.854 (−6.843, −4.853)	<0.001
Vascular access types				
Central venous catheter (CVC)	1.384	3.991 (3.974, 4.008)	–	<0.001
Arteriovenous graft (AVG)	0.261	1.298 (1.290, 1.305)	–	<0.001
Other dialysis access	0.027	1.027 (0.987, 1.070)	–	0.201
Arteriovenous fistula (AVF)	Ref	Ref	–	–
Hospital affiliation				
Free-standing[d]	0.023	1.023 (1.004, 1.042)	–	0.017
Hospital	Ref	Ref	–	–
Group member				
Yes	0.098	1.103 (1.085, 1.122)	–	<0.001
No	Ref	Ref	–	–
Number of dialysis stations				
18–24	0.023	1.023 (1.011, 1.036)	–	<0.001
25 or more	0.048	1.049 (1.033, 1.065)	–	<0.001
17 or fewer	Ref	Ref	–	–
Sine function	−0.023	–	–	<0.001
Cosine function	−0.008	–	–	<0.001

Note. CI, confidence interval.
[a]Negative binomial mixed model adjusts for vascular access type, seasonal factors (sine: sin (2*π*month/12 and cosine: cos(2*π*month/12)) and location/hospital affiliation.
[b]Percent change equals (aRR-1)×100.
[c]Data modeled at facility-month level, aRR and percent change is calculated at yearly level.
[d]Location could be freestanding or a freestanding location owned by a hospital.

downward annual trend was sustained after March 2020, when the World Health Organization declared COVID-19 a pandemic and US states began issuing stay-at-home orders.[6,7] Persons with CVC access had significantly higher IVAS rates than those with other access types. IVAS rates peaked in August each year, which mirrors seasonal variation patterns of hospital-acquired bloodstream infections, particularly central-line associated BSIs.[8]

A heightened commitment to infection prevention and antimicrobial stewardship during the study period, specifically in persons receiving outpatient hemodialysis, may explain decreasing IVAS rates. In 2009, the Centers for Disease Control and Prevention (CDC) developed the Core Interventions for Dialysis Bloodstream Infections[a] and, in 2016, created a partnership called the Making Dialysis Safer for Patients Coalition[b] to prevent hemodialysis-related infections. Both initiatives promoted the implementation of infection prevention practices, including BSI surveillance, hand hygiene, and catheter care practices, which may mitigate the downstream need for antimicrobial therapy, particularly in patients with CVC access, when implemented effectively.

Sustained declines in IVAS rates during the early COVID-19 pandemic coincided with an expert consensus publication by the CDC and the American Society of Nephrology in October 2020, which emphasized strategies decreasing unnecessary antimicrobial prescribing in dialysis centers.[9] Additionally, in March 2021, the

[a]https://www.cdc.gov/dialysis-safety/hcp/clinical-safety/index.html
[b]https://www.cdc.gov/dialysis-safety/making-dialysis-safer-coalition/index.html

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United States prioritized COVID-19 vaccination in persons receiving outpatient maintenance dialysis, resulting in 64.5% of 483,602 persons being partially or fully vaccinated by June 2021.[10] Social distancing measures, adherence to transmission-based precautions, and high vaccination rates among hemodialysis patients may have led to decreased rates of febrile illness that would have otherwise prompted empiric antimicrobial therapy. At the same time, lower IVAS rates could also be explained by patient avoidance of healthcare settings during the early pandemic when sick, which could disproportionally affect the numerator of IVAS rates.

This study has some limitations. Although facilities have incentives to report to NHSN, reporting consistency and quality may depend on resources and protocol adherence. However, NHSN performs quarterly data validations on random Dialysis Safety Module samples. Although the random effects mixed model accounts for facility number and heterogeneity, a sensitivity analysis of continuous reporters did not find a meaningful impact of unbalanced reporting. This analysis cannot explain the appropriateness of the antimicrobial therapy administered. Additional data that might support a clinical indication for treatment, such as symptoms during the event or whether the IVAS was new versus a continuation from another healthcare setting,[3] were part of protocol updates during different years across the study period and, thus, not individually analyzed. Furthermore, conventional antimicrobial use measures, including duration of therapy, type of antimicrobial, de-escalation protocols, or prescribing for infection prophylaxis, are not part of the DE form. Until antimicrobial use measures are incorporated into the NHSN DE protocol, understanding the clinical impact of IVAS is limited.

Annual IVAS rates decreased in outpatient hemodialysis centers from 2012 to 2021, including a period of sustained decline during the early COVID-19 pandemic. Increased awareness of infection prevention practices, antimicrobial stewardship, and COVID-19 mitigation measures in dialysis clinics, such as vaccination and transmission-based precautions, may explain enduring trends during the pandemic. Additional stewardship measures in the NHSN DE form might clarify how clinical factors contribute to IVAS incidence and better describe the impact of interventions in dialysis facilities.

Data availability statement. Line-level data are not made publicly available in accordance with the NHSN Agreement to Participate and Consent. Publicly available data are prepared in aggregate on the NHSN website to protect against the identification of patients and healthcare facilities.

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