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Infection control Surveillance of dialysis events at outpatient hemodialysis centers in Saudi Arabia: A 3-year national data

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SUMMARY

Background: Monitoring dialysis events is very important in evaluating the risk of infection and antimicrobial use among this group of vulnerable patients. The objective was to calculate rates of dialysis events at outpatient hemodialysis centers in Saudi Arabia.

Methods: A retrospective cohort study of dialysis events collected from 152 outpatient hemodialysis centers in 20 Saudi regions between January 2019 and December 2021. The Saudi Health Electronic System Network (HESN) was used to report data from participating centers. Dialysis events included in-unit intravenous antimicrobial start, positive blood culture, and infection (pus, redness, and swelling) at the vascular access site.

Results: A total of 125,761 patient months of surveillance were monitored. The most frequent type of dialysis event was the in-unit intravenous antimicrobial start at 0.75 per 100 patient months, followed by positive blood culture at 0.41, and finally, local access of the infection site at 0.34. The rates of dialysis events were highest, with temporary central lines at 4.36, permanent central lines at 1.87, arteriovenous graft at 0.35, and finally, arteriovenous fistula at 0.17. After adjusting for the differences in the type of vascular access, the rates of dialysis events in the Saudi HESN were lower, 54%–83%, than those of the American National Healthcare Safety Network (NHSN, $P<0.001$ for each) and a less extent 27%–55% lower when compared with the published results from Chinese people.

Conclusions: The current findings provide benchmarking data for different dialysis events that can promote fair comparisons and interest in dialysis event surveillance.

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Introduction

Renal replacement therapies include hemodialysis, peritoneal dialysis, and kidney transplantation [1]. Dialysis is usually indicated when the glomerular filtration rate drops below 10 ml/min in non-diabetic patients and below 15 ml/min in diabetic patients [2]. Chronic hemodialysis is a life-long treatment in patients who cannot undergo kidney transplantation. Renal replacement therapies, including hemodialysis, are known to have a significant negative impact on the patient's quality of life [1]. The combined prevalence of renal replacement therapy in Saudi Arabia is estimated at 294 per million population, and more than 20,000 patients are on dialysis [3].

Hemodialysis patients are at high risk of infections due to recurrent hospital visits, invasive devices, multiple comorbid conditions, and diminished immune status [4,5]. Additionally, several factors in the hemodialysis system and its water source can promote bacterial contamination, especially gram-negative bacteria [4]. The risk of bacteremia in dialysis patients is 26 times higher than in the general population [6]. Additionally, hemodialysis patients are at a high risk of infection with multidrug-resistant organisms, but the ratio of resistant bacteria in hemodialysis patients compared with the general population remains unclear [6,7]. Infection in hemodialysis patients can lead to serious complications, including increased hospitalization, treatment cost, antimicrobial use, and subsequent microbial resistance and death [8]. Infection is the second cause of death in hemodialysis patients after cardiovascular diseases [9].

Monitoring and feedback reports on the infection and related events in dialysis patients can help target improvement projects and assess infection preventive strategies [10]. Studies reporting the outcomes of dialysis events surveillance in Saudi Arabia are limited and confined mainly to one center or a healthcare system [11,12]. National surveillance of dialysis events shifted to electronic surveillance in 2019 [13]. The objective of this study was to calculate the overall and type-specific incidence rates of dialysis events at outpatient hemodialysis centers in Saudi Arabia. Additionally, we aim to calculate standardized infection ratios (SIR) compared to major international benchmarks.

Methods

Study design and setting

This retrospective cohort study of dialysis events occurred between January 1st, 2019, and December 31st, 2021. Data were collected from 152 hemodialysis outpatient centers in 20 regions in Saudi Arabia. Data were entered into the Saudi Health Electronic System Network (HESN). This electronic surveillance system enables infection control practitioners to report healthcare-associated infections from different centers in all regions of Saudi Arabia [13]. The staff at the participating hemodialysis centers monitored hemodialysis patients according to the NHSN 2018 surveillance guidelines for dialysis events [14]. Subsequently, the dialysis events were entered into the HESN from respective centers per the Saudi Ministry of Health (MOH) guidelines [13].

Participants

All patients who received chronic hemodialysis at the included 152 hemodialysis outpatient centers during the study period were included in the study. Those who received peritoneal dialysis or acute hemodialysis were excluded. No age or sex restrictions were applied.

Study outcomes

Three types of dialysis events were monitored per standard NHSN definitions and the Saudi MOH guidelines [13,14]. They included in-unit intravenous antimicrobial start, positive blood culture, and local signs of infection (pus, redness, and swelling) at the vascular access site. Additionally, access-associated bacteremia and vascular access infections were calculated. To be included in the analysis, there must be 21 or more days from one dialysis event type to the diagnosis of another event of the same type. Events re-diagnosed within 21 days from a similar diagnosis were considered duplicates and excluded. More than one dialysis event type may be recorded simultaneously from the same patient (multiple events). Denominator data were defined as the number of hemodialysis outpatients treated in the participating centers during the first two working days of each month (patient months). The dialysis event and the denominator data were stratified by vascular access type. Vascular access types included arteriovenous fistula (AVF), arteriovenous graft (AVG), and venous catheter, which included both tunneled (permanent) central line and non-tunneled (temporary) central line.

Statistical analysis

Categorical data were presented as frequency and percentage. Rates of dialysis events were calculated by dividing the number of dialysis events by the number of patient months and multiplying the result by 100. Overall and type-specific dialysis events were expressed per 100 patient months by vascular access type. The calculated rates were compared to dialysis event rates published by the US NHSN and other major benchmarks [11,12,15–17]. Significant differences between the Saudi HESN and the benchmarks were examined using Z-test. The SIR was calculated to compare the Saudi HESN rates with major benchmarks (NHSN and Chinese data) after adjusting for differences in the type of vascular access between Saudi HESN data and the benchmarks. The SIR was calculated by dividing observed dialysis events by expected dialysis events (given the number of patient months of surveillance in Saudi Arabia and the rate of dialysis events in the standard population; NHSN and the published results from Chinese people [16,20]. Finally, percentiles of rates of different centers were created to be used as a national benchmark for hemodialysis centers in Saudi Arabia. *P*-values <0.05 were considered significant. SPSS (Version 27.0. Armonk, NY: IBM Corp) was used for all statistical analyses.

Results

During the study, 125,761 patient months of surveillance were monitored. As shown in Table I, 152 dialysis centers in 20

Table I
Number of patients by year, Saudi Health Electronic System Network (HESN), 2019–2021

Region	2019	2020	2021	Total
AlAhsa	0	925	3232	4157
AlBahah	113	303	1234	1650
AlJouf	0	484	1488	1972
AlMedina AlMonawarah	1215	1851	8447	11513
AlQassim	37	478	5886	6401
AlQrayat	0	65	788	853
AlQunfutha	0	0	1387	1387
AlTaif	0	73	1603	1676
Asir	354	1486	7840	9680
Beshah	112	976	1613	2701
Eastern	74	312	4341	4727
Hafer AlBatin	31	1268	2250	3549
Hail	420	1410	3029	4859
Jazan	2193	3217	8929	14339
Jeddah	0	679	6461	7140
Makkah	2541	3468	9404	15413
Najran	280	1312	2002	3594
Northern Borders	490	1332	1973	3795
Riyadh	2550	6102	13983	22635
Tabouk	306	1422	1992	3720
Total (number)	**10716**	**27163**	**87882**	**125761**
Total (%)	**8.5%**	**21.6%**	**69.9%**	**100.0%**

Saudi regions contributed data to the current analysis. The data were distributed across three years (2019 through 2021); however, approximately 70% were collected during 2021.

Table II shows the pooled means of rates of dialysis events by type of vascular access and years. A total of 1,080 dialysis events of different types were detected during 125,761 patient months of surveillance, representing a rate of 0.86 per 100 patient months. The rates were highest with temporary central lines at 4.36 per 100 patient-months, followed by permanent central lines at 1.87 per 100 patient-months, arteriovenous graft at 0.35 per 100 patient-months, and finally arteriovenous fistula at 0.17 per 100 patient-months. The same order of decreasing infection risks was observed in almost all type-specific dialysis events, with the highest being temporary central lines and the lowest being arteriovenous fistula. Being the largest contributor, the rates for 2021 were closest to the overall rates. Except for local access site infection, the rates for 2019 were lower than the overall rates. The most frequent type of dialysis events was in-unit intravenous antimicrobial start at 0.75 per 100 patient-months, followed by vascular access infection at 0.62 per 100 patient-months, positive blood culture at 0.41 per 100 patient-months, access-related bloodstream infection at 0.38 per 100 patient-months, and finally local access site infection 0.34 per 100 patient-months.

Table III shows the percentiles of the distribution of rates of dialysis events. For overall dialysis events, the 50th percentile rate was close to the pooled mean rate of 0.86 and 0.85 per 100 patient months, respectively. The 10th and 25th percentile rates were 0.08 and 0.52 per 100 patient-months, respectively. Meanwhile, the 75th and 90th percentile rates were 1.12 and 1.31 per 100 patient-months, respectively. The inter-quartile range (difference between 75th and 25th percentile rates)

Table II
Pooled means of rates[a] of dialysis events by type of vascular access and years, Saudi health electronic system network (HESN), 2019–2021

	Events	Patient months	Overall rate	Rates per year		
				2019	2020	2021
Overall dialysis events						
AV fistula	124	73287	0.17	0.26	0.13	0.17
AV graft	12	3410	0.35	0.00	0.00	0.46
Permanent CL	895	47962	1.87	1.39	1.41	2.14
Temporary CL	48	1102	4.36	3.09	3.74	5.27
Total	1080	125761	0.86	0.77	0.81	0.89
In-unit IV antimicrobial start						
AV fistula	113	73287	0.15	0.21	0.12	0.16
AV graft	12	3410	0.35	0.00	0.00	0.46
Permanent CL	781	47962	1.63	1.15	1.24	1.87
Temporary CL	43	1102	3.90	3.09	3.74	4.30
Total	949	125761	0.75	0.64	0.72	0.78
Positive blood culture						
AV fistula	21	73287	0.03	0.07	0.04	0.02
AV graft	2	3410	0.06	0.00	0.00	0.08
Permanent CL	473	47962	0.99	0.82	0.84	1.08
Temporary CL	21	1102	1.91	1.23	2.10	1.95
Total	517	125761	0.41	0.40	0.46	0.40
Local access site infection						
AV fistula	46	73287	0.06	0.07	0.02	0.07
AV graft	4	3410	0.12	0.00	0.00	0.15
Permanent CL	360	47962	0.75	0.37	0.45	0.94
Temporary CL	19	1102	1.72	1.85	2.34	1.17
Total	429	125761	0.34	0.22	0.26	0.38
Access-related bloodstream infection						
AV fistula	17	73287	0.02	0.02	0.04	0.02
AV graft	2	3410	0.06	0.00	0.00	0.08
Permanent CL	437	47962	0.91	0.68	0.78	1.00
Temporary CL	20	1102	1.81	1.23	1.87	1.95
Total	476	125761	0.38	0.32	0.43	0.37
Vascular access infection						
AV fistula	62	73287	0.08	0.14	0.06	0.08
AV graft	6	3410	0.18	0.00	0.00	0.23
Permanent CL	682	47962	1.42	1.01	1.05	1.64
Temporary CL	32	1102	2.90	2.47	3.04	2.93
Total	782	125761	0.62	0.54	0.59	0.64

[a] Rate per 100 patient months. AV, arteriovenous; CL, central line.

was highest with temporary central lines at 7.41 per 100 patient-months, followed by permanent central lines at 1.61 per 100 patient-months, arteriovenous graft 0.25 per 100 patient-months, and finally arteriovenous fistula 0.14 per 100 patient-months. The same observations were repeated in all types of dialysis events, with the highest being temporary central lines and the lowest being arteriovenous fistula/graft. The details of the percentile rates for different types of dialysis events by type of vascular access are shown in Table III. The interquartile ranges were between zero and 7.41.

As shown in Figure 1, there were apparent seasonal variations in the rates of both overall and type-specific dialysis events. There were two seasonal peaks in March and between August and October. As shown in Figure 2, overall dialysis events and, to a lesser extent, type-specific dialysis events were highest in the first two-quarters of the study period. This

Table III
Pooled means and percentiles of the distribution of rates[a] of dialysis events by type of vascular access, Saudi health electronic system network (HESN), 2019–2021

	Events	Patient months	Overall rate	Percentiles[b]				
				10	25	50	75	90
Overall dialysis events								
AV fistula	124	73287	0.17	0.00	0.05	0.13	0.19	0.40
AV graft	12	3410	0.35	0.00	0.00	0.00	0.25	1.10
Permanent CL	895	47962	1.87	0.12	1.05	2.07	2.66	3.63
Temporary CL	48	1102	4.36	0.00	0.00	1.36	7.41	15.96
Total	1080	125761	0.86	0.08	0.52	0.85	1.12	1.31
In-unit IV antimicrobial start								
AV fistula	113	73287	0.15	0.00	0.04	0.13	0.19	0.36
AV graft	12	3410	0.35	0.00	0.00	0.00	0.25	1.10
Permanent CL	781	47962	1.63	0.11	0.81	1.81	2.41	3.50
Temporary CL	43	1102	3.90	0.00	0.00	0.00	6.97	9.49
Total	949	125761	0.75	0.07	0.42	0.69	1.02	1.16
Positive blood culture								
AV fistula	21	73287	0.03	0.00	0.00	0.00	0.05	0.12
AV graft	2	3410	0.06	0.00	0.00	0.00	0.00	0.10
Permanent CL	473	47962	0.99	0.02	0.47	0.92	1.12	2.73
Temporary CL	21	1102	1.91	0.00	0.00	0.00	3.19	6.90
Total	517	125761	0.41	0.01	0.21	0.31	0.62	0.87
Local access site infection								
AV fistula	46	73287	0.06	0.00	0.00	0.05	0.10	0.12
AV graft	4	3410	0.12	0.00	0.00	0.00	0.00	0.20
Permanent CL	360	47962	0.75	0.03	0.35	0.82	1.29	2.01
Temporary CL	19	1102	1.72	0.00	0.00	0.00	2.85	6.90
Total	429	125761	0.34	0.03	0.17	0.32	0.49	0.62
Access-related bloodstream infection								
AV fistula	17	73287	0.02	0.00	0.00	0.00	0.04	0.11
AV graft	2	3410	0.06	0.00	0.00	0.00	0.00	0.10
Permanent CL	437	47962	0.91	0.02	0.47	0.89	1.10	2.27
Temporary CL	20	1102	1.81	0.00	0.00	0.00	3.11	6.90
Total	476	125761	0.38	0.01	0.19	0.30	0.50	0.85
Vascular access infection								
AV fistula	62	73287	0.08	0.00	0.04	0.08	0.11	0.19
AV graft	6	3410	0.18	0.00	0.00	0.00	0.00	0.36
Permanent CL	682	47962	1.42	0.06	0.81	1.53	2.12	3.20
Temporary CL	32	1102	2.90	0.00	0.00	0.00	4.66	15.72
Total	782	125761	0.62	0.05	0.35	0.70	0.82	1.03

AV, arteriovenous; CL, central line.
[a] Rate per 100 patient months.
[b] Percentiles were created from regional rates.

was followed by a decrease for three quarters and then a gradual increase until the end of the study. The latter included a peak during the fourth quarter of 2020.

Table IV compares type-specific dialysis events in HESN with major benchmarking reports. All type-specific HESN rates were considerably lower than corresponding NHSN and Kuwaiti rates. The difference was biggest for in-unit IV antimicrobial start and smallest for positive blood culture and access-related bloodstream infection. Some HESN rates (in-unit IV antimicrobial start and local access site infection) were slightly lower. In contrast, others (positive blood culture and access-related bloodstream infection) were slightly higher than the published rate from Chinese people. Most type-specific HESN rates were considerably lower than previous single-center Saudi data, with a bigger difference in older data than recent data.

Figure 3 benchmarks type-specific HESN rates with major multicenter benchmarking data using SIR. Type-specific HESN SIRs were 54%–83% lower than NHSN after adjusting for the difference in the type of vascular access ($P<0.001$ for each). The difference was biggest (83%) with in-unit IV antimicrobial start and smallest (54%) with access-related bloodstream infection. Type-specific HESN SIRs were 27%–55% lower than the published Chinese rates after adjusting for the difference in the type of vascular access ($P<0.001$ for each). The difference was biggest (55%) with local access site infection and smallest (27%) with positive blood culture.

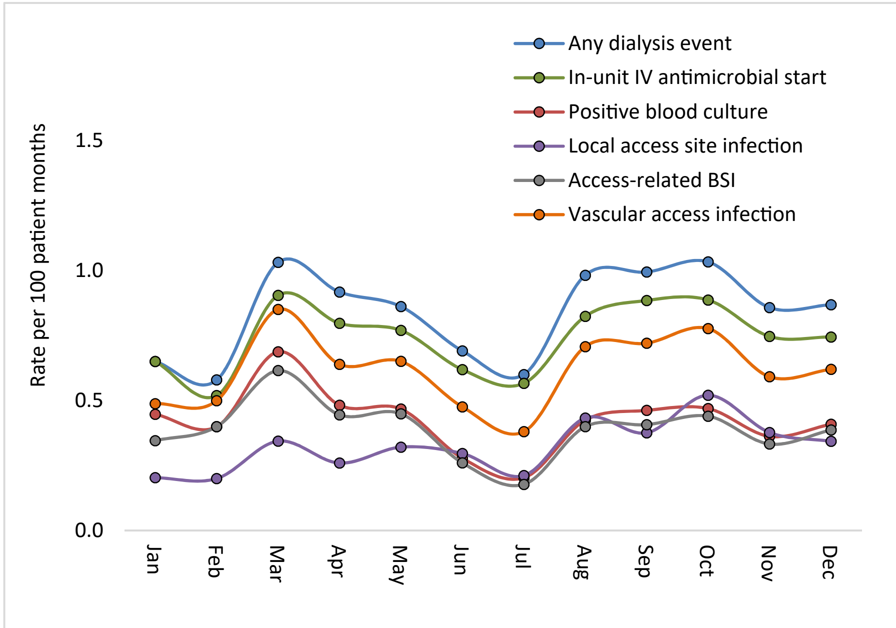

Figure 1. Seasonal variations of the rates of dialysis events, Saudi Health Electronic System Network (HESN), 2019–2021.

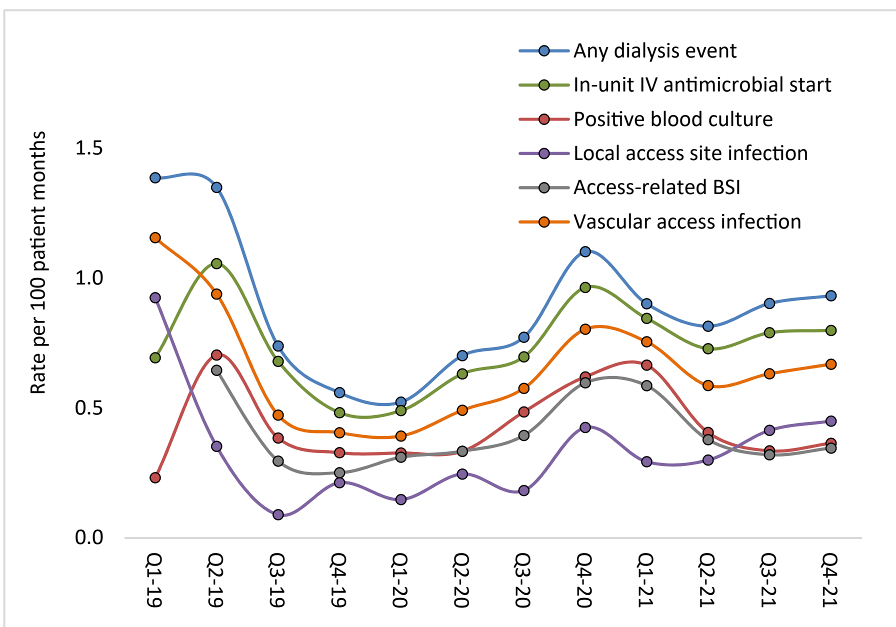

Figure 2. Trend of the rates of dialysis events, Saudi Health Electronic System Network (HESN), 2019–2021.

Discussion

This study reports dialysis event rates from 152 dialysis centers in 20 Saudi regions. The study provides unique benchmarking data of Saudi Arabia dialysis events and highlights the risk of infection and the use of antimicrobials among this vulnerable patient population.

Rates by type of events

The most frequent type of dialysis events in the study was an in-unit intravenous antimicrobial start, followed by positive blood culture, and finally, local access site infection. Similarly, the in-unit intravenous antimicrobial start was the most frequent type of dialysis event in almost all previous studies, ranging between approximately 1.0 and 9.0 per 100 patient months [11,12,15–20]. The current rate (0.75 per 100 patient-months) was close to Chinese data (0.91–1.1 per 100 patient-months) [16,20] but much lower than NHSN data (3.1–3.3 per 100 patient-months) [15,19]. The higher frequency of in-unit intravenous antimicrobial start in this study and previous studies can be explained by the fact that these antimicrobials (that had a rate of 0.75 per 100 patient-months) are used in the treatment of both positive blood culture and local access

Table IV
Comparisons of the rates of dialysis events between the Saudi health electronic system network (HESN, 2019–2021) and major benchmarking reports

	Saudi HESN (Current data)	NHSN [15]	China [16]	Kuwait [17]	KFSHRC [11]	KAMC-R [12]
	2019–2021	2014	2019	2013–2016	2014–2017	2008–2009
In-unit IV antimicrobial start						
AV fistula	0.15	2.07	0.54	7.22	0.63	2.33
AV graft	0.35	2.63	1.96	7.03	1.18	3.24
CVC	1.68	7.91	3.11	9.90	5.59	14.77
Total	**0.75**	**3.27**	**0.91**	**8.99**	**1.59**	**7.63**
Positive blood culture						
AV fistula	0.03	0.26	0.05	0.23	0.20	0.86
AV graft	0.06	0.39	0.00	0.39	0.37	0.54
CVC	1.01	2.16	1.36	1.06	3.26	10.71
Total	**0.41**	**0.64**	**0.23**	**0.78**	**0.75**	**5.00**
Local access site infection						
AV fistula	0.06	0.31	0.30	0.23	0.23	0.10
AV graft	0.12	0.48	1.96	0.00	0.59	0.54
CVC	0.77	2.35	1.36	1.30	3.03	0.60
Total	**0.34**	**0.72**	**0.46**	**0.93**	**0.78**	**0.33**
Access-related bloodstream infection						
AV fistula	0.02	0.16	0.02	NA	NA	0.57
AV graft	0.06	0.27	0.00	NA	NA	0.00
CVC	0.93	1.83	1.36	NA	NA	9.69
Total	**0.38**	**0.49**	**0.20**	**0.75**	**NA**	**4.40**
Vascular access infection						
AV fistula	0.08	0.46	0.32	NA	NA	0.67
AV graft	0.18	0.75	1.96	NA	NA	0.54
CVC	1.46	4.19	2.72	NA	NA	10.29
Total	**0.62**	**1.21**	**0.66**	**1.64**	**NA**	**4.73**

*Rate per 100 patient months. NHSN, US National Healthcare Safety Network; KFSHRC, King Faisal Specialist Hospital & Research Center; KAMC-R, King Abdulaziz Medical City-Riyadh; AV, arteriovenous; CVC, central venous catheter.

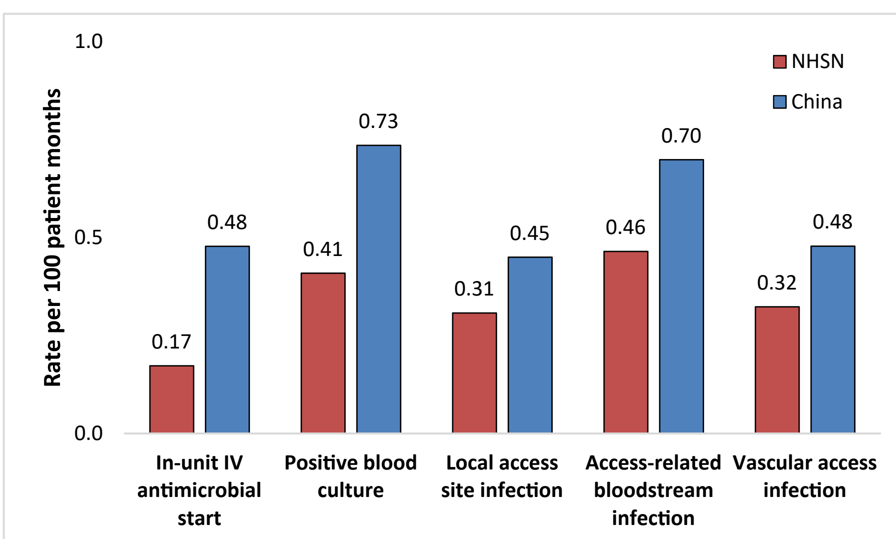

Figure 3. Standardized infection ratios of different dialysis events in the Saudi health electronic system network (HESN, 2019–2021) as compared with the US National Healthcare Safety Network (NHSN, 2014) and a multicenter dialysis data from Eastern China (2019) after adjustment for the difference in the type of vascular access.

infection (both had a rate of 0.74 per 100 patient-months). The lower rates of in-unit intravenous antimicrobial start in this study compared with NHSN (3.1–3.3 per 100 patient-months) [15,19] may reflect the lower rates of positive blood culture and local access infection in this study (both were 0.74 per 100 patient-months) and may be partially caused by under-estimation. This underestimation may be related to easier access to inpatient use of antimicrobials (in largely free governmental hospitals), which cannot be documented as per the study design.

Rates by type of access

The rates of dialysis events in this study were highest with temporary central lines (4.36 per 100 patient-months), followed by permanent central lines (1.87 per 100 patient-months), arteriovenous graft (0.35 per 100 patient-months), and finally arteriovenous fistula (0.17 per 100 patient-months). The same order of decreasing infection risks was observed in almost all previous studies [11,15,16,18,19]. The role of central lines, both temporary and permanent, in developing dialysis bacteremia is very well known [21,22]. It was suggested that infection prevention, especially bacteremia in dialysis patients, requires decreasing the prevalence of central line use and increasing the prevalence of fistula [21–23]. However, approximately one-third to half of dialysis patients have central lines due to the difficulty of establishing AV fistulas and grafts [22,23]. This is especially evident in patients who have just started dialysis; therefore, early diagnosis and effective treatment of infectious complications are crucial to improve outcomes. [21]. Interestingly, 61% of the patients in this study had AV fistula/graft compared with 39% who had central lines. While AV fistula/graft in this study was slightly higher than the previous local data from the National Guard clinics (58%) [12], it is still lower than recently reported in the NHSN data (62.8%) [15,19]. In the United States, the fistula-first initiative set a 66% goal for AV fistula among patients on dialysis [24]. Additionally, the initiative successfully increased the frequency of AV fistula by 50% and consequently decreased infection [24].

Rates overtime

Both overall and type-specific dialysis event rates in the study showed an apparent seasonal variation. The strong peak in August to October may be related to the higher risk of bacteremia during summer [25]. Higher heat and humidity during summer months facilitate bacterial growth and compromise preventive measures [25]. The same has been observed with peritoneal dialysis-associated peritonitis during the summer months [26]. The relative increase in dialysis events during 2020 and 2021 may be related to the challenges of the COVID-19 pandemic, including staffing and access [27]. However, some studies reported lower antimicrobial use and bloodstream infection during early COVID pandemic [28]. Additionally, data obtained during the study varied, with more dialysis centers contributing data in 2021 than in 2019.

Benchmarking Saudi data

After adjusting for the difference in the type of vascular access, the SIR of dialysis events of different types were much lower (54%–83%) in the Saudi HESN compared with NHSN rates ($P<0.001$ for each). The HESN dialysis event SIRs were also 27%–55% lower than reported dialysis events in China, as observed in Figure 3. The lower SIRs may reflect a real lower risk of infection and, consequently antimicrobial use in Saudi centers; however, since the lower risk is observed after comparing Saudi HESN data with both US NHSN and Chinese data, it may point to under-reporting. It is worth noting that although HESN offers a lot of validation to the entered data, it is still the staff's responsibility at the different centers to accurately and thoroughly report the dialysis event data. The current findings provide benchmarking percentiles for different dialysis events that can be readily used for comparisons by local centers that contributed and those that did not contribute data to this study. This type of data can promote positive competition and interest in dialysis surveillance between different centers.

Strengths and limitations

This study has several strengths. It is considered the first national study to report the rates of dialysis events in all Saudi regions. The sample size of the study is substantial, with more than 125,000 patient months of monitoring. The current findings provide benchmarking percentiles for different dialysis events that can be readily used for comparisons by local centers that contributed and those that did not contribute data to the study. The data were collected using an HESN electronic system, which offers a lot of validation standards for the reported data. Multiple types of infection outcomes were monitored in this study; however, some study limitations should be acknowledged. For example, there was a lack of microbiological data, which was not supported well by the old system. Consequently, antimicrobial resistance was not available. Finally, the reported data was not constant across the study period, which may complicate the interpretation of trends over time. Most of these limitations are supposed to be solved with the newly created version of HESN. Additionally, such limitations do not undermine the importance of this study, which contributes to the knowledge of infection risk among dialysis patients in Saudi Arabia.

Conclusions

This study is considered the first national study to report the rates of dialysis events in all Saudi regions. The study findings showed that the most frequent type of dialysis event was the in-unit intravenous antimicrobial start. As expected, the rates of dialysis events were highest with temporary central lines. After adjusting for the difference in the type of vascular access, the rates of dialysis events in the Saudi HESN were lower than those of NHSN and Chinese data. The possibility of under-reporting may indicate the importance of data validation, frequent staff training, and adopting a no-blame culture. The current findings provide benchmarking percentiles for different dialysis events that can be readily used for comparisons by local centers.

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Credit author statement

Mohammed ALQahtani, Aiman El-Saed: Conceptualization, data analysis, Methodology.

Faisal Alsheddi, Ahlam H. Alamri, Atef M Shibl: Data collection, writing, and original draft preparation.

Khalid H. Alanazi: Visualization, Supervision.

All authors interpreted the data analysis, contributed to the first draft of the manuscript, and critically revised the final manuscript.

Conflict of interest statement

All authors have no known competing financial or personal interests that could have influenced the work reported in this paper.

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Ethical considerations

This study obtained the required ethical approval from the central Institutional Review Board of the Ministry of Health, protocol number (HA-01-R-058). Additionally, administrative approval from the Saudi Ministry of Health was obtained before abstracting the data. Waiver of informed consent was obtained through the Institutional Review Board due to the nature of this retrospective study and to preserve patients' anonymity.

Data availability statement

Data are available from the corresponding authors with reasonable request and after the permission of the Institutional Review Board of the Ministry of Health.

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