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Original Article

Application of center for disease control and prevention standardized antimicrobial administration ratio to an Indian hospital

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Abstract

Background: Rigorous antibiotic stewardship is advised by international societies to combat rising antibiotic resistance. A major component of these programs is the metric used for antibiotic consumption measurement. A method for standardized antimicrobial administration ratio (SAAR) is suggested by the Centre for Disease Control & Prevention—National Healthcare Safety Network (NHSN).

Objectives: We applied the SAAR method to calculate antibiotic consumption in a tertiary care hospital in India. We also validated a limited sampling approach to calculate SAAR.

Method: The prospective study was conducted in three medical intensive care units over a period of 12 months. Monthly antibiotic consumption was measured by the hospital electronic records. Limited sampling was performed by weekly bedside review of the antibiotic orders. Formulae for SAAR calculation were derived from the NHSN guide. SAAR obtained by electronic records and limited sampling were compared to validate this approach.

Results: SAAR was calculated as >1 for an Indian hospital (1.49 by electronic records and 1.43 by limited sampling approach). The difference between the two ratios was not statistically significant ($P = .47$).

Conclusions: SAAR in our setting is 1.49, which is slightly higher than the NHSN benchmark. Antibiotic usage (AU) risk adjustment based on data from the NHSN might not be adequate for calculating SAAR for Indian hospitals. There is a need to perform AU risk factor analysis for Indian settings for better defining SAAR in Indian context. The limited sampling approach can be adapted for calculation of SAAR in settings with limited resources.

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Background

India faces a lot of challenges in managing infections with multidrug resistant organisms and controlling their spread within the hospital environment as well as the community.[1,2] Hence, there is a need to design a robust antibiotic stewardship program based on measurable metrics specific to the local clinical scenario. For antibiotic stewardship activities, our hospital has an antibiotic policy in place, both for targeted and empiric therapy. However, we need an antibiotic usage (AU) metric which could be internally and externally benchmarked over time. The Centre for Disease Control & Prevention (CDC)—National Healthcare Safety Network (NHSN) developed the SAAR, as a standardized metric of AU by the hospitals in the United States.[3] It calculates the observed-to-predicted ratio of AU for a specified group of antibiotics. This model was developed for seven adult and eight pediatric SAAR antibiotic categories. The data for developing SAAR guidelines was captured from 2,156 adult and 170 pediatric locations across 457 hospitals in the United States. Risk factors were stratified according to locations and antibiotic classes were used to define different predicated AUs. The SAAR can be used both for internal and external benchmarking purposes, allowing a hospital to compare AU with itself over time and to compare AU with a national benchmark. The SAAR can be a valuable indicator to help hospitals identify patient-care locations or groups of antibiotics that require more robust antibiotic stewardship, and outlying SAAR values are intended to prompt further investigation into potential antibiotic overuse or underuse. Facilities can compare their AU to the AU of a standard reference population (ie, NHSN baseline). There is a lack of studies from India for AU using this novel method.

For capturing antibiotic use, electronic records are desirable in healthcare settings. However, most hospitals in India lack these

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facilities. Although we have electronic records in our own hospital for capturing antibiotic prescription data, we validated a limited sampling approach to help facilities without electronic records calculate SAAR. This limited sampling approach (point-prevalence survey, PPS) can be more easily applied in the resource-limited settings in India and other developing countries.

Material and methodology

This prospective observational study was conducted during 2022–2023 at Medanta hospital which is a tertiary care referral hospital in northern India, with 1,200 beds including 300 ICU beds. The protocol for the study was approved by the institute's ethics committee (MIER/1276/2021).

Three adult medical ICUs, comprising of 66 beds, were selected for the present study. Antibiotics used for empiric as well as targeted therapy were included in the data. We selected the category broad-spectrum antibiotics predominantly used for hospital-onset infections.[3] This was decided based upon the ten antibiotics mentioned in this category which match antibiotics used most frequently in Indian ICUs. We also included eight more antibiotics used in our ICUs. The antibiotics included in the data were as follows: Amikacin, Amoxicillin/Clavulanic acid, Aztreonam, Cefepime, Ceftazidime, Ceftriaxone, Cefoperazone/Sulbactam, Cefuroxime, Colistin, Gentamicin, Imipenem/cilastatin, Linezolid, Meropenem, Piperacillin/Tazobactam, Polymyxin B, Teicoplanin, Tigecycline, Tobramycin, Vancomycin.

Antibiotic data was captured by the electronic medical records (EMR) as well as the bedside rounds of the clinical pharmacology and infection control teams.

i. **Observed antibiotic days**: Observed antibiotic days included any amount of a specific antibiotic agent administered in a calendar day to a particular patient.[3] Antibiotic days are the SAAR numerator.
ii. **Days present**: Days present included the aggregate number of patients housed in a patient-care location or facility anytime throughout the day during a calendar month.[3]
iii. **Predicted antibiotic days**: Predicted antibiotic days were the days of therapy predicted for each SAAR agent category and location, or group of locations, through predictive modeling applied to nationally aggregated AU data by the NHSN based on the data from hospitals in the U.S.[3] Predicted antibiotic days are the SAAR denominator. Negative binomial regression was used for AU risk adjustment as per the NHSN protocol.[3] This protocol uses a set of fixed parameters to predict the risk of AU in the specific hospital locations. The formula for the negative binomial regression was used by exponentiating the solution, and multiplying by the number of days present. This provided the estimate for predicted antibiotic days.

Model for calculating predicted antibiotic days

The binary factors along with their regression coefficient (parameter estimate) used in the SAAR predictive model were taken from the CDC NHSN SAAR module[3] as were relevant for our set-up as given in Table 1.

Predicted antibiotic days was calculated with the help of the exponent calculator[4]:

e(−2.3357 + 1.0084 + 0.1734 + 0.1091) X days present#

Days present = inpatient days

Table 1. The binary factors and regression coefficient (parameter estimate) used in the SAAR predictive model based on NHSN SAAR module which were applicable in the study

Binary factor	Regression coefficient
Location type: Medical ICU	1.0084
ICU beds : ≥8	0.1734
Average length of stay: ≥3.6 days	0.1091

Intercept = (−2.3357) as mentioned for the predictive model for broad-spectrum antibiotics predominantly used for hospital-onset infections in SAAR guide.[3]

Calculation of SAAR

SAAR was calculated using the formula as follows:

$$\text{SAAR} = \frac{\text{Observed antibiotic days of therapy}}{\text{Predicted antibiotic days of therapy}}$$

Estimation of SAAR based on EMR ($SAAR_{EMR}$)

Overall data for each month for all three ICUs was captured monthly from the EMR. This included observed antibiotic days and days present compiled monthly for the ICUs. $SAAR_{EMR}$ was calculated based on the above formula.

Estimation of SAAR based on PPS by bedside rounds ($SAAR_{PPS}$)

We obtained antibiotic point-prevalence estimates using the methods described by WHO and Global PPS.[5] Briefly, members of the infection control team reviewed paper medication administration records at 8 AM for each patient present in the ICU on a particular day (Wednesday) every week for a period of twelve months. This included antibiotics being administered or ordered for that day and total inpatients counted manually. Limited patient-level information was also recorded.

Two SAARs were calculated based on the two methods of data collection—by EMR and by Point-Prevalence Survey. The SAARs were compared and P value for significance was calculated based on the formula for comparison of ratios using the medcalc software (MedCalc Software Ltd. (Version 22.014; accessed November 1, 2023).

Results

The study was conducted for a period of twelve months, from three medical ICUs at Medanta, Gurgaon, India. A total of 1,108 patients were audited during the study. Average age was 55.2 ± 18.5 years. Overall, 67.9% patients were males. Majority of the AU was empiric (93.3%). Average length of antibiotic therapy was 6.3 days. Sepsis was the common diagnosis in majority of the patients at the time of admission (41.3%), followed by the involvement of respiratory system (32%), gastrointestinal system (25.7%), genitourinary system (12.8%) and central nervous or cardiac system (12.2%). 38% of the patients had more than one organ system involved at the time of admission.

Of 1,108 patients audited, 75.7% had central vascular catheters, 70% has indwelling urinary catheters and 24.7% were intubated.

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Table 2. Comparison of estimate of SAAR based on two methods—electronic records and point-prevalence survey

Months	Observed antibiotic days	Inpatient days (Days present)	Predicted days calculation	Predicted antibiotic days	$SAAR_{EMR}$	Observed antibiotic days	Inpatient days (Days present)	Predicted days calculation	Predicted antibiotic days	$SAAR_{PPS}$	P (COMPARISON OF TWO RATES)
Apr-22	**728**	1448	0.3518*1448	**509.41**	1.42	**18**	45	0.3518*45	**15.83**	1.14	0.34
May-22	**520**	1096	0.3518*1096	**385.57**	1.35	**26**	72	0.3518*72	**25.33**	1.03	0.16
Jun-22	**480**	955	0.3518*955	**335.97**	1.43	**25**	46	0.3518*46	**16.18**	1.54	0.68
Jul-22	**614**	1280	0.3518*1280	**450.3**	1.36	**57**	79	0.3518*79	**27.79**	2.05	0.005
Aug-22	**762**	1450	0.3518*1450	**510.11**	1.49	**39**	93	0.3518*93	**32.72**	1.19	0.16
Sep-22	**784**	1221	0.3518*1221	**429.55**	1.83	**17**	39	0.3518*39	**13.72**	1.24	0.1
Dec-22	**367**	784	0.3518*784	**275.81**	1.33	**28**	52	0.3518*52	**18.29**	1.53	0.46
Jan-23	**780**	1163	0.3518*1163	**409.14**	1.91	**33**	65	0.3518*65	**22.87**	1.44	0.11
Feb-23	**328**	576	0.3518*576	**202.64**	1.62	**12**	26	0.3518*26	**9.15**	1.31	0.49
Mar-23	**507**	899	0.3518*899	**316.26**	1.6	**17**	32	0.3518*32	**11.25**	1.51	0.84
Apr-23	**315**	529	0.3518*529	**186.1**	1.69	**11**	10	0.3518*10	**3.51**	3.12	0.06
May-23	**422**	1164	0.3518*1164	**409.49**	1.03	**9**	21	0.3518*21	**7.38**	1.21	0.59
Overall	**6607**	12565		**4420**	1.49	**292**	580		**204.04**	1.43	0.47

The results of $SAAR_{EMR}$ and $SAAR_{PPS}$ for three medical ICUs for twelve months calculated are as given in Table 2. These two results were compared individually for each month as well as overall for 12 months as shown in Table 1. $SAAR_{EMR}$ and $SAAR_{PPS}$ calculated for 12 months were 1.49 and 1.43 respectively. This difference was not statistically significant ($P > .05$).

Discussion

Managing and preventing infections with multidrug resistant organisms are a challenge for healthcare settings. Antibiotic stewardship helps prescribers use antibiotics judiciously, reducing the selection pressure on bacteria. Hence, we need to design a robust antibiotic stewardship program based on objective measurable metrics specific to our clinical scenario.[6] The CDC developed the Standardized Antimicrobial Administration Ratio (SAAR), as a standardized metric of antibiotic use available to facilities reporting data to NHSN. This metric has been used by various stewardship programs to measure antibiotic consumption.[7,8] We used the same NHSN risk modeling update for calculation of predicted antibiotic use.[9] Our aim was to calculate SAAR and validate a limited sampling approach for settings where EMRs are rarely available. Our average SAAR was 1.4, which was slightly higher than the predicated AU for the ICUs in the U.S which is 1.

We included more antibiotics than were mentioned in the category of broad-spectrum antibiotics. This was imperative because AU profile of patients in the U.S. is different from that in India due to multiple reasons. It is noted that the consumption of broad-spectrum antibiotics in the community is high due to availability of antibiotics and fixed-dose combinations over-the-counter.[10] This in turn affects the selection of antibiotic in previously exposed patients, especially at tertiary care centers. This also had an impact on our SAAR and resulted in a higher SAAR.

We also tried to compare a point-prevalence study approach for calculating AU. This is of special interest because antibiotic stewardship programs are inadequately manned and may not be backed by electronic records.[11–13] This makes daily bedside rounds for capturing antibiotic days impractical in most hospitals. We concluded that the limited sampling approach did not result in significant deviations in SAAR when compared with that calculated by electronic data from information systems.

It should be noted that the SAAR value does not necessarily measure appropriateness and should be used in combination with other information to make clinical decisions regarding antibiotic prescribing. A value of one or less than one in SAAR does not mean AU is low or appropriate, because it is only a ratio compared with a standard benchmark. Furthermore, SAAR predictions are based upon NHSN locations, which might have different patient characteristics than those in Indian ICUs.[14,15] Although the average age is comparable to that in western countries, a higher proportion of patients are sicker, self-paying and given terminal discharge in Indian ICUs.[16] Furthermore, antibiotic grouping used in the NHSN methodology might not be directly applicable to Indian hospitals. Also, as pointed out by Shively et al., grouping of certain antibiotics such as fluoroquinolones and cephalosporins together might make important stewardship work invisible if one relies only upon SAAR as an indicator of stewardship activities.[17] As SAAR does not adjust for patient-level risk factors, further research into these factors is needed to benchmark the AU data. Given a different baseline patient population in Indian ICUs, it is suggested that the risk factor analysis for calculation of SAAR in India should be undertaken for locally relevant results.

Conclusion

SAAR based on negative binomial regression used for AU risk adjustment gave a slightly higher value for Indian hospital which may be normal in our setting. Risk modeling for Indian ICUs taking into account the patient population and antibiotics used is required for better benchmarking at local levels. The estimates based on PPS are broadly comparable to that based on electronic records. In view of this the PPS may be recommended for use in estimation of SAAR for hospitals which do not have the facilities of EMRs.

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Declarations. Human Ethics and Consent to Participate declarations: not applicable.

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