Original Article
J Immunol Clin Microbiol. 2020;5(1):41-49

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J Immunol Clin Microbiol

The Adjusted Standardized Infection Ratio and Cumulative Attributable Difference for Central Line-Associated Bloodstream Infections and Catheter-Associated Urinary Tract Infections in Turkey

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Abstract

Background: Standardized infection ratio (SIR) is a new measure used in surveillance of healthcare-associated infections, and cumulative attributable difference (CAD) is another new measure complementary to SIR. This study aims to calculate the SIR and the CAD for central line-associated bloodstream infection (CLABSI) and catheter-associated urinary tract infection (CAUTI) at the national level in 2017.

Materials and Methods: Predicted number of CLABSI and CAUTI for the SIR and the CAD calculation was calculated by the formulas obtained from the negative binomial models using the national surveillance data in 2016 and the SIRs and CADs calculated for the data in 2017.

Results: The average length of stay and hospital type are available in both models. While the CLABSI model has also ICU branch and number of hospital beds, the CAUTI model has catheter utilization ratio and the number of ICU beds. The standardized CLABSI ratio was 0.87 (95% CI:0.85-0.90) and the standardized CAUTI ratio was 0.84 (95% Cl:0.82-0.86). The CAD for CLABSI and CAUTI was 697.26 and 659.76, respectively. 59.4% of the ICUs reached 25% reduction target for CLABSI and the 67.8% of the ICUs for CAUTI.

Conclusions: The SIRs and the CADs in this study proof that Turkey has achieved success in the implementation of infection control measures in the ICUs for CLABSI and CAUTI, however, this ought to be improved further. We hope that our findings shall be guiding and encouraging for other countries.

Key words: healthcare-associated infections surveillance, standardized infection ratio, cumulative attributable difference, urinary tract infection, bloodstream infection.

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Introduction

Prevention and control for central line-associated bloodstream infections (CLABSIs) and catheter-associated urinary tract infections (CAUTIs) are still two of the foremost components for combat healthcare-associated infections (HAIs) in Turkey. According to the Annual, National HAI Reports overall CLABSI rates have decreased from 5.68 to 2.81 per 1000 central line days from 2008 to 2017. In 2017 CLABSI rates vary between 0.8 and 6.3 per 1000 urinary catheter days among intensive care unit (ICU) branches. Similarly, overall CAUTI rates have decreased from 5.22 to 1.59 per 1000 device days from 2008 to 2017. CAUTI rates vary between 0.1 and 3.4 per 1000 device days among ICU branches in 2017 (1-3).

Notwithstanding on that achievement, the height of the rates preserve itself and have to be reduced further. However, it is getting more difficult having achieve a specific reduction in these rates from this point. To give a better direction to infection control measures the use of the rates may no longer provide more information. Therefore, it has been necessary to use a measure that provides more information about the development of infection such as standardized infection ratio (SIR). In this way, infection control measures can be planned more effectively (4-7).

The SIR is used as the primary summary measure in HAI surveillance. It is useful to monitor the change of HAIs over time at national, regional, institutional or unit level. Its calculation is similar to the calculation of the standardized mortality ratio. The SIR compares the observed/predicted number of HAIs with a certain standard population. The crude SIR does not provide more information than the ratio of rates unless it is calculated as stratified. However, the stratified SIR provides us with additional information only about the stratification variable or variables. When the SIR is obtained by multivariate analysis, the effect of many factors related to the development of infection can be taken into account simultaneously. It is called as adjusted SIR (4, 7, 8).

The cumulative attributable difference (CAD) is another summary measure used to monitor HAIs as a complement to the SIR. The CAD aims to identify and prioritize the hospitals or units in which the greatest reduction in infection control measures can be achieved. The CAD is calculated by subtracting a predetermined numerical prevention target from the observed number of infections. To identify the hospital or units with which preventive measures will have the greatest impact to achieve the nationally-targeted reduction (4, 8, 9).

In this study, it is aimed at modelling multivariate regression to calculate the predicted number of CLABSIs and CAUTIs and to calculate the SIR and the CAD for CLABSI and CAUTI at the national level.

Materials and Methods

Data Collection: Surveillance of device-associated infections is mandatory in the 2^{nd}. and the 3^{rd}. level ICUs in all hospitals in Turkey since 2005. The surveillance is carried out by the Infection Control Committees in all hospitals and the data is entered into the National HAI Surveillance Network (‘’USHIESA’’) by infection control nurses. The surveillance is patient-based and active prospective type. The diagnostic criteria adapted from CDC criteria are used for the surveillance according to the National Surveillance Guide (10, 11). In this study, the database used for The National HAI Surveillance Network Summary Report 2016 was used for modelling and the database used for The National HAI

Surveillance Network Summary Report 2017 was used for calculating the SIRs and the CADs. The permission for data use was granted by the Deputy Minister of Health Ministry of Turkey.

Data analysis: Statistical analysis was performed using SPSS version 15-0 (SPSS Inc., USA). Fisher exact test, which is one of the tests recommended by the National Healthcare Safety Network in the United States of America in confidence interval calculations, was preferred for ease of use and the calculations were made in Excel programme.

Following formula was used for calculation of the SIRs for CLABSI and CAUTI. SIR = Observed number of infections / Predicted number of infections

Calculation of the CAD for CLABSI and CAUTI following formula was used:

CAD = Observed number of infections – (SIR target x Predicted number of infections)

The SIR target was chosen to be 0.75 for both CLABSI and CAUTI. This means a 25% CLABSI and CAUTI reduction is targeted at the national level. ICUs were ranked from the largest to the smallest in terms of their CAD. SIR and CAD were used separately to determine the ICUs that should be prioritized to achieve the %25 reduction target (4).

Calculation of the predicted number of infection:

Predicted number of CLABSI and CAUTI was calculated by the formulas obtained from the negative binomial models. The number of CLABSI and the number of CAUTI was the dependent variable for both negative binomial model with a logarithmic link function. Offset terms were the natural logarithm of central line days and the natural logarithm of urinary catheter days. Independent variables in the database were region, province, number of hospital beds, number of ICU beds, hospital type, ICU branch, the average length of stay, central line utilization ratio and urinary catheter utilization ratio. The negative binomial regression method was preferred instead of Poisson regression because conditional variances of the distributions of CLABSI and CAUTI numbers were greater than the conditional means (over-spread). The data of the neonatal ICUs were not included in the models. Because the birth weight category is an important risk factor and also umbilical catheter-associated bloodstream infections are monitored separately from CLABSI in neonatal ICUs. The data of the ICUs are combined according to the ICU branch in hospitals. When a hospital had the same ICU branch more than one, the ICUs were considered as a single ICU. For instance, if there were three anaesthesia and reanimation ICUs in a hospital, the data of these three ICUs were combined and it has been accepted that there was only one anaesthesia and reanimation ICU for that hospital. Similarly, the ICUs were not evaluated separately according to the ICU level. For instance, for a hospital with both the 2^{nd}. and 3^{rd}. level cardiology ICUs, the ICUs were considered as a single ICU. The number of hospital beds and ICU beds are categorized according to their median and quartiles for each model as nominal variables and are considered as a continuous variable separately for the models. The hospital type variable has four categories as a state hospital, education research hospital, university hospital and private hospital. In the database, 22 categories of ICU branches were analysed in six categories for the models. The mean length of hospital stay was calculated by dividing the number of patients to the patient days. Device utilization ratios are the variables present in the database and are categorized based on their median.

Results

The algorithm for the incorporation of hospitals and units into the models is shown in Figure 1. The number of ICUs was 1372 and 1631 in the CLABSI model and the CAUTI model, respectively. For the CLABSI model goodness of fit (Pearson chi-squared value/degree of freedom) was 1.159 and p-value for Omnibus test was <0.001. For the CAUTI model goodness of fit (Pearson chi-squared value/degree of freedom) was 1.561 and p-value for Omnibus test was <0.001. The negative binomial models for CLABSI and CAUTI are summarized in Table 1 and Table 2, respectively.

Table 1. The negative binomial model for central line-associated bloodstream infection.

Parameter	Parameter Estimate		Standard Error	p value	Incidence rate ratio	95% CI*
Intercept	-7.2239		0.1448	<0.0001	0.0007	0.0005 - 0.0010
State Hospital	0.4516		0.1335	0.0007	1.5709	1.2092 - 2.0407
Education Research Hospital	1.1805		0.1413	<0.0001	3.2561	2.4686 - 4.2949
University Hospital	1.5850		0.1415	<0.0001	4.8791	3.6973 - 6.4386
Private Hospital	Reference		-	-	1.0000	-
Other ICUs†	0.6043		0.2355	0.0103	1.8300	1.1535 - 2.9034
Anaesthesia and Reanimation ICU	0.6328		0.1171	<0.0001	1.8828	1.4967 - 2.3685
Mixed ICU	0.5392		0.1203	<0.0001	1.7146	1.3544 - 2.1705
Paediatric ICU	0.3407		0.1567	0.0297	1.4059	1.0342 - 1.9113
Adult Internal Branches ICU	0.3938		0.1103	0.0004	1.4826	1.1944 - 1.8403
Adult Surgical Branches ICU	Reference		-	-	1.0000	-
Average length of stay	0.0206		0.0067	0.0022	1.0208	1.0075 - 1.0344
Number of hospital beds < 150	-0.3881		0.1313	0.0031	0.6783	0.5244 - 0.8775
Number of hospital beds >= 150	Reference		-	-	1.0000	-

*CI: Confidence interval. †ICU: Intensive care unit.

Table 2. The negative binomial model for catheter-associated urinary tract infection.

Parameter	Parameter Estimate	Standard Error	p value	Incidence rate ratio	95% CI*
Intercept	-7.7173	0.1011	<0.0001	0.0004	0.0004 - 0.0005
State Hospital	0.7642	0.0838	<0.0001	2.1472	1.8222 - 2.5303
Education Research Hospital	1.1165	0.0909	<0.0001	3.0543	2.5560 - 3.6497
University Hospital	1.4122	0.0972	<0.0001	4.1049	3.3931 - 4.9659
Private Hospital	Reference	-	-	1.0000	-
Average length of stay	0.0389	0.0068	<0.0001	1.0396	1.0258 - 1.0536
Number of ICU† beds < 9	-0.1844	0.0640	0.0040	0.8316	0.7335 - 0.9427
Number of ICU beds >= 9	Reference	-	-	1.0000	-
Urinary catheter utilization ratio >= 0.90	0.3413	0.0708	<0.0001	1.4067	1.2245 - 1.6161
Urinary catheter utilization ratio < 0.90	Reference	-	-	1.0000	-

*CI: Confidence interval. †ICU: Intensive care unit.

The observed CLABSI number was 4999 and the predicted CLABSI number was 5735.65 in 2017. The standardized CLABSI ratio was 0.87 (95% CI: 0.85 - 0.90) and the number of CLABSIs to be prevented to reach the national 25% reduction target was 697.26. 59.4% of the ICUs reached this national target.

The observed CAUTI number was 5611 and the predicted CAUTI number was 6668.32 in 2017. The standardized CAUTI ratio was 0.84 (95% Cl: 0.82 - 0.86) and the number of CAUTIs to be prevented to reach the national 25% reduction target was 659.76. 67.8% of the ICUs reached this national target. The summary of the overall results for ICUs by branch and hospital type in 2017 is shown in Table 3.

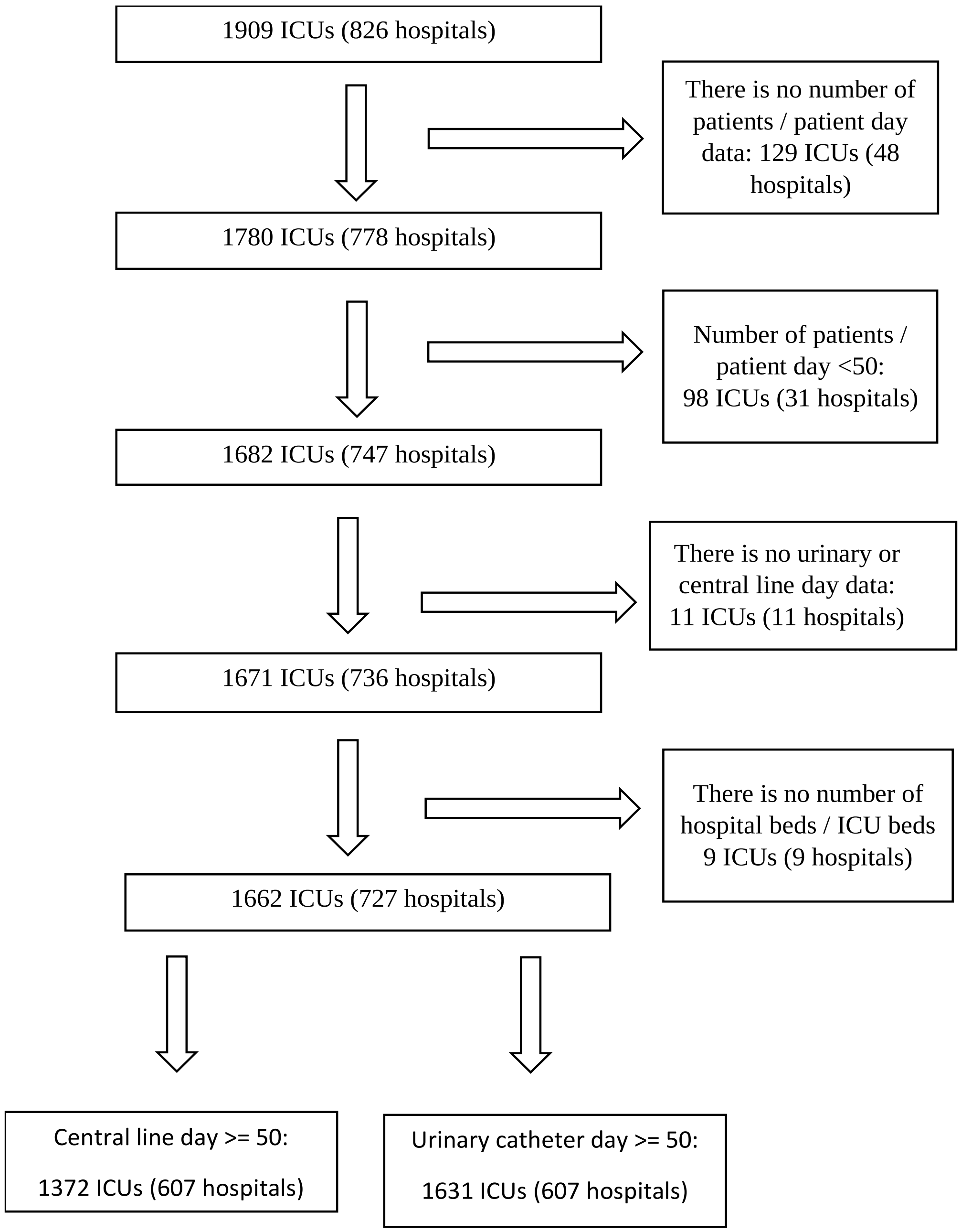
Table 3. The summary of the overall results for ICUs by branch and hospital type.

Parameter	CLABSI*	CAUTI†	Denominator for % account
Number of hospitals in the database	826	826	-
Number of hospitals in the analysis	613 (74.2%)	615 (74.2%)	Number of hospitals in the database
Number of ICUs‡ in the database	2692	2693	-
Number of ICUs in the analysis	1472 (54.7%)	1465 (54.5%)	Number of ICUs in the database
Number of ICUs with no SIR§ (the predicted number of infections is <1.0)	697 (47.3%)	484 (33.1%)	Number of ICUs in the analysis
Number of ICUs with SIR	775 (52.7%)	981 (66.9%)	Number of ICUs in the analysis
Number of ICUs with SIR> 1.0	275 (35.5%)	285 (29.1%)	Number of ICUs with SIR
Number of ICUs with SIR> 1.0 and p <0.05	114 (41.5%)	132 (46.3%)	Number of ICUs with SIR> 1.0
Number of ICUs with SIR <1.0	500 (64.5%)	696 (70.9%)	Number of ICUs with SIR
Number of ICUs with SIR <1.0 and p <0.05	122 (24.7%)	185 (26.6%)	Number of ICUs with SIR <1.0
Number of ICUs with positive CAD?	353 (45.5%)	471 (32.2%)	Number of ICUs in the analysis
Number of ICUs with negative CAD	422 (54.5%)	994 (67.8%)	Number of ICUs in the analysis

*CLABSI: Central line-associated bloodstream infection. †CAUTI: Catheter-associated urinary tract infection. ‡ICU: Intensive care unit. §SIR: Standardized infection ratio. ?CAD: Cumulative attributable diffrerence.

The number of CLABSIs that should be prevented to achieve the 25% reduction target was 1250. The total observed number of CAUTIs was 5611 and the number of CAUTIs that should be prevented to achieve the 25% reduction target was 1403. The number of ICUs that should be targeted when sorted by CAD to achieve the 25% reduction target was 76 and 71 for CLABSI and CAUTI, respectively. The number of ICUs that should be targeted when sorted by SIR to achieve the 25% reduction target was 135 and 108 for CLABSI and CAUTI, respectively. The number of infections to be prevented if ICUs are selected by SIR ranking as the amount of ICUs determined by CAD ranking was 866.4 and 1089.8 for CLABSI and CAUTI, respectively.

Figure 1. The algorithm for the incorporation of hospitals and units into the models.



Discussion

The overall CLABSI rate in Turkey was 2.89 and 2.81 per 1000 device days according to the National HAI report in 2016 and 2017, respectively. Thus in 2017, the rate of CLABSI decreased by 5.7% compared to 2016. The adjusted SIR calculated according to the CLABSI model indicates that CLABSI is 13% less than predicted. The overall CAUTI rate in Turkey was 1.78 and 1.59 per 1000 device days according to the National HAI Report in 2016 and 2017, respectively. Thus in 2017, the rate of CAUTI decreased by 10.7% compared to 2016 2, 3. The adjusted SIR calculated according to the CAUTI model indicates that CAUTI is 16% less than predicted.

However, the 25% reduction target has not been achieved at the national level. Nevertheless, 45.5% of ICUs for CLABSI and 32.2% of ICUs for CAUTI achieved at least 25% reduction target. This reduction is consistent with the decreasing trend in the rates observed in previous years in Turkey 1-3. SIR was <1.0 in 64.5% of the ICUs for CLABSI and 70.9% of the ICUs for CAUTI. The calculated SIR, CAD and CAD rankings of the ICUs were reported to all hospitals so that it can be used to guide their infection control programs. The SIR and CAD have not been calculated for the ventilator-associated event (VAE) because Turkey is in the transition from ventilator-associated pneumonia to VAE (2, 3).

Since hospital type, ICU branch, the average length of stay and number of hospital beds has included in the model, it should be thoroughly understood that infection control measures need to be developed for an ICU with a SIR>1.0 (or a positive CAD) for CLABSI. Whereas the calculated high rates may tend to be explained by factors other than infection control measures, almost impossible to replace, such as hospital type, bed number and so on. Therefore, the use of SIR for the feedback to the hospitals can be more effective in convincing the hospital managers and the other relevant staff of the need to develop infection control measures. This is also the case for CAUTI (4, 5).

Hospitals or ICUs can be ranked from the largest to the smallest in terms of their CAD. In this case, the hospitals or the ICUs that are in the first places are the most important ones in terms of infection control and prevention measures. Prioritization of the ICUs at the national level according to CAD is more efficient than their priorities according to SIR. Because in this case, it would be sufficient to intervene in terms of infection control measures to fewer units. In this study, CAD ranking was found more efficient than SIR ranking for both CLABSI and CAUTI. It should be noted, however, that this does not mean that the development of infection control measures is not necessary for the ICUs other than the prioritized ICUs.

When looked at the current models developed by the Centers for Disease Control and Prevention (CDC), it is seen that the standard errors of parameter estimations are similar to our models. Compared to the CDC models, the models in this study contain similar variables with some differences (4). In the models in this study, there is no data for wards and neonatal ICUs. There are also some differences in the categories of some variables such as ICU branch, number of hospital beds. In this study, ICU branches could be evaluated in five categories. Especially the ICUs classified as mixed units may have been insufficient in determining risk than the other ICUs because of its heterogeneity. This may be one reason why the ICU branch for CAUTI could not include in the model. Moreover, the use of urinary catheters among the ICUs in Turkey is more homogeneous (1-3). Remarkably, while the number of hospital beds for CLABSI was included in the model, the number of ICU beds for CAUTI was included. Hospitals with more beds may be considered to serve more severe patients and therefore they may be considered to have a greater risk of developing CLABSI. Since the use of the urinary catheter is more common and perhaps less related to the severity of patients, the number of hospital beds may not have been included in the CAUTI model. Including the number of ICU beds in the CAUTI model can be explained by poor urinary catheter care in larger ICUs. However, such a situation for the central line is not expected.

As a result, the use of CLABSI and CAUTI rates in Turkey, as in many countries, is a habit. However, the use of adjusted SIR and CAD, which gives more information than the rates, maybe more realistic in planning interventions at national, regional, institutional and unit level (4, 12, 13). Nowadays, it is suggested to use the adjusted measures in HAI surveillance. So, it should be used standardized utilization ratio to evaluate the device utilization use as complementary to SIR (4, 14).

Conclusion

The SIRs and CADs at the national level in this study show that Turkey has achieved success in the implementation of infection control measures in the ICUs for CLABSI and CAUTI however, this can be improved further. Since the variables such as the number of beds, hospital type, ICU branch, average length of stay in the models can significantly adjust the impact of the differences of patient populations among the ICUs, the SIR and the CAD can allow for more accurate inferences by enabling healthier comparisons. It is expected that the feedback to the hospitals using these measures will accelerate infection control and prevention efforts. We hope that our findings shall be guiding and encouraging for other countries.

Acknowledgments

Thank you to all infection control nurses and physicians in all hospitals in Turkey for providing us this data.

Ethics Committee Approval: NA
Informed Consent: NA
Peer-review: Externally peer-reviewed.
Conflict of Interest: No conflict of interest was declared by the author.
Financial Disclosure: The author declared that this study has received no financial support.

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