Turk J Public Health
Available online at: http://dergipark.org.tr/tjph/
doi:10.20518/tjph.989565

TURKISH JOURNAL OF PUBLIC HEALTH

ORIGINAL ARTICLE / ORİJİNAL MAKALE

Standardized infection ratio: Can we still reliably use the national invasive device- associated infection models in intensive care units in Turkey?

Standardize enfeksiyon oranı: Türkiye'de yoğun bakım ünitelerinde ulusal invaziv araç ilişkili enfeksiyon modellerini hala güvenilir bir şekilde kullanabilir miyiz?

Can Hüseyin Hekimoğlu[a], Selda Şahan[b], Esen Batır[c] Emine Yıldırım Gözel[c], Dilek Altun[c], Gülen Pehlivantürk[d] Muhammet Çömçe[e] Fatih Kara[f]

[a] Assoc Prof, Turkish Ministry of Health, Department of Communicable Diseases, Ankara, Turkey.
[b] Specialist, Turkish Ministry of Health, Department of Tuberculosis, Ankara, Turkey.
[c] Nurse,Turkish Ministry of Health, Department of Communicable Diseases, Ankara, Turkey.
[d] Specialist,Turkish Ministry of Health, Department of Communicable Diseases, Ankara, Turkey.
[e] Specialist, Turkish Ministry of Health, General Directorate of Public Health, Ankara, Turkey.
[f] Assoc Prof, Turkish Ministry of Health, General Directorate of Public Health, Specialist, Ankara, Turkey.

Received: 03.09.2021, Accepted: 14.04.2022

ABSTRACT

Objective: Standardized infection ratio (SIR) for ventilator-associated pneumonia (VAP), central line-associated bloodstream infection (CLABSI) and catheter-associated urinary tract infection (CAUTI) has been calculated using formulas obtained from the national models in Turkey since 2016. we aimed to evaluate the current usability of the national models by using 2020 data and whether the models need to be updated.**Methods:** The database used for The National HAI Surveillance Network Summary Report 2020 was used for remodelling. For each type of infection, remodeling was performed with 2020 data using the variables in the national models. The number of CLABSIs, CAUTIs and VAPs was the dependent variable for each negative binomial model with a logarithmic link function. Incidence rate ratios (IRRs) from the repeated models were compared with the national models using 95% confidence intervals. **Results:** In each model, all variables in the national models were again statistically significant (ps<0.05). Although the IRRs were similar for most of the risk factors, the size of the risk for some of them changed significantly between the national models and our models. In the national VAP and CAUTI model, the reference category for hospital type was private hospitals, while in our models, it was state hospitals. In addition, the IRRs for CAUTI in state hospitals, training and research hospitals and university hospitals were significantly lower than in the national model.**Conclusion:** It is necessary to update the coefficients used in the calculation of the predicted infection numbers in the SIR formulas, especially for VAP and CAUTI.

Keywords: Ventilator-Associated Pneumonia, Central Line-Associated Bloodstream Infection, Catheter-Associated Urinary Tract Infection

Correspondence: Can Hüseyin HEKİMOĞLU, Assoc Prof, Public Health Institution of Turkey, Ankara, Turkey. **E-mail:** drchh@hotmail.com **Tel:** +90 5422470718

Cite This Article: Hekimoğlu CH., Sahan S., Batır E., Gozel EY., Altun D., Pehlivantürk G., Comce M., Kara F. Standardized infection ratio: Can we still reliably use the national invasive device- associated infection models in intensive care units in Turkey? Turk J Public Health 2022;20(2):177-185

ÖZ

Amaç: Ventilatör ilişkili pnömoni (VİP), santral kateter ilişkili kan dolaşımı enfeksiyonu (SKİ-KDE) ve kateter ilişkili idrar yolu enfeksiyonu (Kİ-İYE) için standardize enfeksiyon oranı (SIR) 2016 yılından itibaren Türkiye'de ulusal modellerden elde edilen formüller kullanılarak hesaplanmaktadır. Bu çalışmada 2020 yılı verileri kullanılarak ulusal modellerin mevcut kullanılabilirliği ve modellerin güncellenmesinin gerekli olup olmadığının değerlendirilmesi amaçlanmıştır. **Yöntem:** Ulusal Sağlık Hizmeti İlişkili Enfeksiyonlar Sürveyans Ağı Özet Raporu 2020 için kullanılan veri tabanı yeniden modelleme için kullanılmıştır. Her enfeksiyon türü için ulusal modellerdeki değişkenler kullanılarak 2020 verileriyle yeniden modelleme yapılmıştır. SKİ-KDE, Kİ-İYE ve VİP sayısı, logaritmik bağlantı fonksiyonuna sahip negatif binomial modeller için bağımlı değişkendi. Tekrarlanan modellerden elde edilen insidans oranı oranları (IRR'ler), %95 güven aralıkları kullanılarak mevcut ulusal modellerle karşılaştırıldı. **Bulgular:** Her bir modelde, ulusal modellerdeki tüm değişkenler istatistiksel olarak anlamlıydı ($p<0{,}05$). Risk faktörlerinin çoğu için IRR'ler benzer olmasına rağmen, bazılarının risk boyutu ulusal modeller ve çalışmadaki modeller arasında önemli ölçüde değişmiştir. Ulusal VİP ve Kİ-İYE modelinde hastane türü değişkeninin referans kategorisi özel hastaneler iken bu çalışmadaki modellerde referans kategorisi devlet hastaneleridir. Ayrıca devlet hastanelerinde, eğitim ve araştırma hastanelerinde ve üniversite hastanelerinde Kİ-İYE için IRR'ler ulusal modelden önemli ölçüde düşüktü. **Sonuç:** Özellikle VİP ve Kİ-İYE için SIR formüllerinde öngörülen enfeksiyon sayılarının hesaplanmasında kullanılan katsayıların güncellenmesi gerekmektedir.

Anahtar Kelimeler: Ventilatör Ilişkili Pnömoni, Santral Kateter Ilişkili Kan Dolaşımı Enfeksiyonu, Kateter Ilişkili Idrar Yolu Enfeksiyonu

INTRODUCTION

In the context of healthcare-associated infections (HAIs) surveillance, monitoring of inazive device-associated infections is mandatory in the second and the third level intensive care units (ICUs) in all hospitals according to the national HAI surveillance standards in Turkey since 2005. Patient-based, prospective and active HAI surveillance is carried out by the Infection Control Committees (ICCs) in all hospitals. Surveillance data is collected and entered into the National HAI Surveillance Network ("USHIESA") by infection control nurses. The National Surveillance Guide which was prepared by the National Advisory Board and published by the Ministry of Health is used for the diagnostic criteria in the scope of the HAI surveillance.[1-5]

The national level surveillance reports are published annually by the related unit of the Ministry of Health and the feedbacks are sent to the hospitals via the software network. The national reports include infection rates and device utilization ratios with overall means and percentiles since 2008.[6] Standardized infection ratio (SIR) and cumulative attributable difference (CAD) were added to the national reports in 2016; standardized utilization ratio (SUR) was added in 2017. The SIR and CAD calculations cover ICUs (except neonatal ICUs) and are performed for central line-associated bloodstream infection (CLABSI), catheter-associated urinary tract infection (CAUTI) and ventilator-associated pneumonia (VAP). In order to calculate SIR and CAD, the national models were created for each of the three infection types using the 2016 national data.[7,8] All the hospitals can report and provide feedback by the software network with using the formulas which obtained from the models. These new criteria were widely adopted and started to be used throughout the country in a short time.[9-11] In this study, we aimed to evaluate the current availability of the national models by using the data of 2020 and whether the models need to be updated.

METHODS

In our study we used a database which was used for the "National HAI Surveillance Network Summary Report 2020" for remodeling. The study population consists of all patients who were administered invasive devices in the second and third level ICUs (except neonatal ICUs) in Turkey in 2020. The data usage permission was granted by the General Directorate of Public Health, Turkish Ministry of Health.

Statistical Analysis

For each type of infection, remodeling was performed with the data of 2020 using variables used for the national models. The number of CLABSIs, CAUTIs and VAPs were the dependent variables for each negative binomial model with a logarithmic link function. Offset terms were the natural logarithmes of invasive device days (central line days, urinary catheter days, ventilator days). The number of hospital beds and ICU beds were categorized according to their medians in the national models. The hospital type variable had four categories as a state hospital, training and research hospital (TRH), university hospital and private hospital. The ICU types were analysed in six categories.: anesthesiology and reanimation (AR) ICU, mixed ICU, pediatric ICU, adult internal ICU, other ICUs and adult surgical ICU. 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 were categorized based on their medians in 2016. ICUs with an invasive device day of 150 or more were included in the analysis.

Incidence rate ratios (IRRs) obtained from the models in this study were compared with the national models using 95% confidence intervals. The Statistical Package for Social Sciences (SPSS v20.0, SPSS Inc., USA) software was used for statistical analysis. The p value was considered significant if it was lower than 0.05.

RESULTS

The models included 1283 ICUs for VAP, 2151 for CLABSI, and 2543 ICUs for CAUTI. The p values of the omnibus test were found to be <0.0001 for each models. Goodness of fit (Pearson chi-square value/degree of freedom) was 2.504, 1.673 and 4.956 in the VAP, CLABSI and CAUTI models, respectively. The distribution of the variables in the models is shown in Table 1.

Table 1. The distribution of the variables in the models.

Variable	Category	VAP		CLABSI		CAUTI	
		n	%	n	%	n	%
Hospital Type	State Hospital	307	23.9	521	24.2	741	29.1
	TRH	287	22.4	596	27.7	645	25.4
	University Hospital	230	17.9	378	17.6	396	15.6
	Private Hospital	459	35.8	656	30.5	761	29.9
ICU Type	AR ICU	-	-	347	16.1	-	-
	Mixed ICU	-	-	770	35.8	-	-
	Pediatric ICU	-	-	130	6.0	-	-
	Adult Internal ICU	-	-	452	21.0	-	-
	Other ICUs	-	-	35	1.6	-	-
	Adult surgical ICU	-	-	417	19.4	-	-
Number of hospital beds	<150	-	-	556	25.8	-	-
	>=150	-	-	1595	74.2	-	-
Number of ICU beds	< 9	-	-	-	-	1151	45.3
	>=9	-	-	-	-	1392	54.7
Ventilator utilization ratio	>= 0.40	433	33.7	-	-	-	-
	< 0.40	850	66.3	-	-	-	-
Catheter utilization ratio	>= 0.90	-	-	-	-	1779	70.0
	<0.90	-	-	-	-	764	30.0
Average length of stay (day); mean±SD		2.4±5.6		3.6±7.9		1.7±4.5	

AR: Anesthesiology and reanimation; CAUTI: Catheter-associated urinary tract infection; CLABSI: Central line-associated bloodstream infection; ICU: Intensive care unit; TRH: Training and research hospital; VAP; Ventilator-associated pneumonia.

The VAP Model

In the VAP model, all variables were statistically significant like in the national model (Table 2). While the IRRs between the two models were different for the state hospital, they were similar for all other variables (Figure 1). Although state hospital was a risk factor in the national model, we determined it as a protective factor in our study.

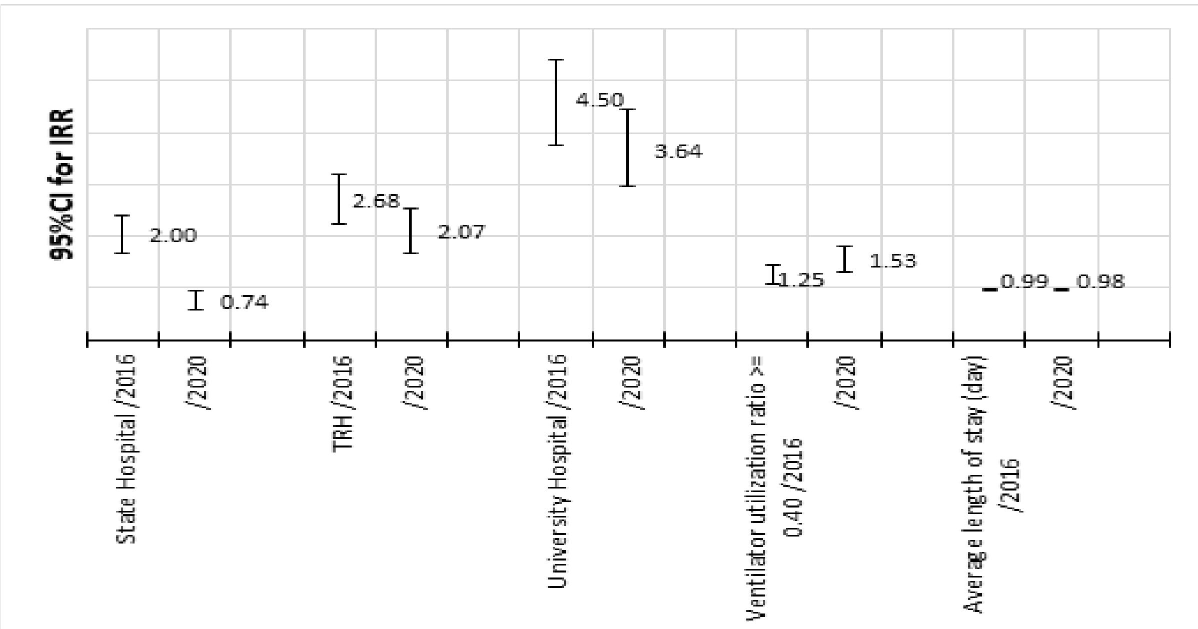
The CLABSI Model

In the CLABSI model, all variables were statistically significant like in the national model (Table 3). All the IRRs between the two models were similar for all variables (Figure 2).

Table 2. The negative binomial model for ventilator associated-pneumonia.

Parameter	Beta	Standart Error	p value	IRR	95%CI for IRR
Intercept	-6.3513	0.0975	0.0000	0.0017	0.0014-0.0021
State Hospital	-0.2996	0.1203	0.0127	0.7411	0.5855-0.9381
TRH	0.7290	0.1042	0.0000	2.0730	1.6899-2.5428
University Hospital	1.2917	0.1037	0.0000	3.6391	2.9698-4.4591
Private Hospital	Reference			1.0000	-
Ventilator utilization ratio >=0.40	0.4234	0.0817	0.0000	1.5272	1.3013-1.7923
Ventilator utilization ratio <0.40	Reference			1.0000	-
Average length of stay (day)	-0.0204	0.0055	0.0002	0.9798	0.9693-0.9905

Dependent Variable: Number of VIPs; offset = Ln (ventilator-days)
CI: Confidence interval; IRR: Incidence rate ratio; TRH: Training and research hospital.

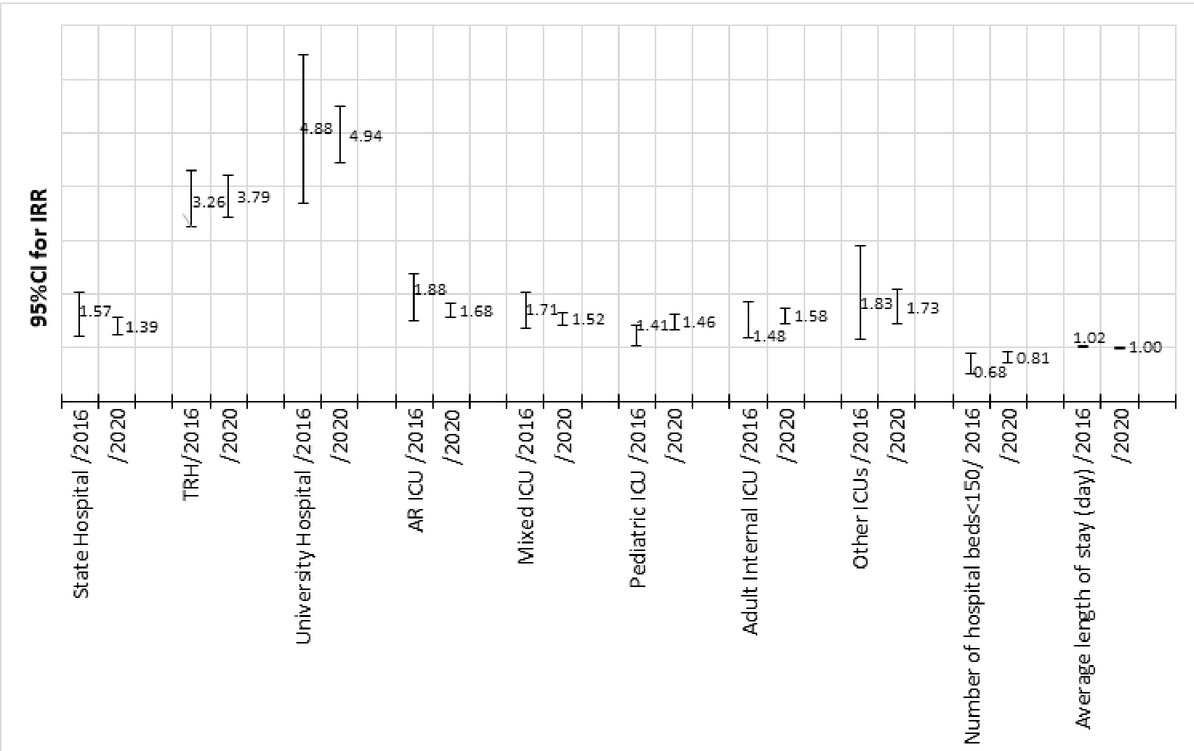


AR: Anesthesiology and reanimation; CI: Confidence interval; IRR: Incidence rate ratio; TRH: Training and research hospital.
Figure 1. Incidence rate ratios with 95% confidence intervals in the 2016 and 2020 ventilator-associated pneumonia model.

Table 3. The negative binomial model for central line-associated bloodstream infection.

Parameter	Beta	Standart Error	p value	IRR	95%CI for IRR
Intercept	-7.127	0.0630	<0.0001	0.0008	0.0007-0.0009
State Hospital	0.331	0.0603	<0.0001	1.3920	1.2369-1.5667
TRH	1.332	0.0539	<0.0001	3.7891	3.4092-4.2113
University Hospital	1.597	0.0549	<0.0001	4.9396	4.4357-5.5008
Private Hospital	Reference			1.0000	-
AR ICU	0.521	0.0400	<0.0001	1.6832	1.5563-1.8204
Mixed ICU	0.422	0.0421	<0.0001	1.5247	1.4308-1.6559
Pediatric ICU	0.378	0.0504	<0.0001	1.4599	1.3226-1.6114
Adult Internal ICU	0.458	0.0434	<0.0001	1.5813	1.4524-1.7217
Other ICUs	0.549	0.0967	<0.0001	1.7323	1.4333-2.0937
Adult surgical ICU	Reference			1.0000	-
Number of hospital beds<150	-0.214	0.0595	0.0003	.8077	0.0718-0.9076
Number of hospital beds>=150	Reference			1.0000	-
Average length of stay (day)	0.005	0.0015	0.0014	1.0048	1.0018-1.0078

Dependent Variable: Number of CLABSIs; offset = Ln (central line-days)
AR: Anesthesiology and reanimation; CI: Confidence interval; IRR: Incidence rate ratio; TRH: Training and research hospital.



AR: Anesthesiology and reanimation; CI: Confidence interval; IRR: Incidence rate ratio; TRH: Training and research hospital.

Figure 2. Incidence rate ratios with 95% confidence intervals in the 2016 and 2020 central line-associated bloodstream infection model.

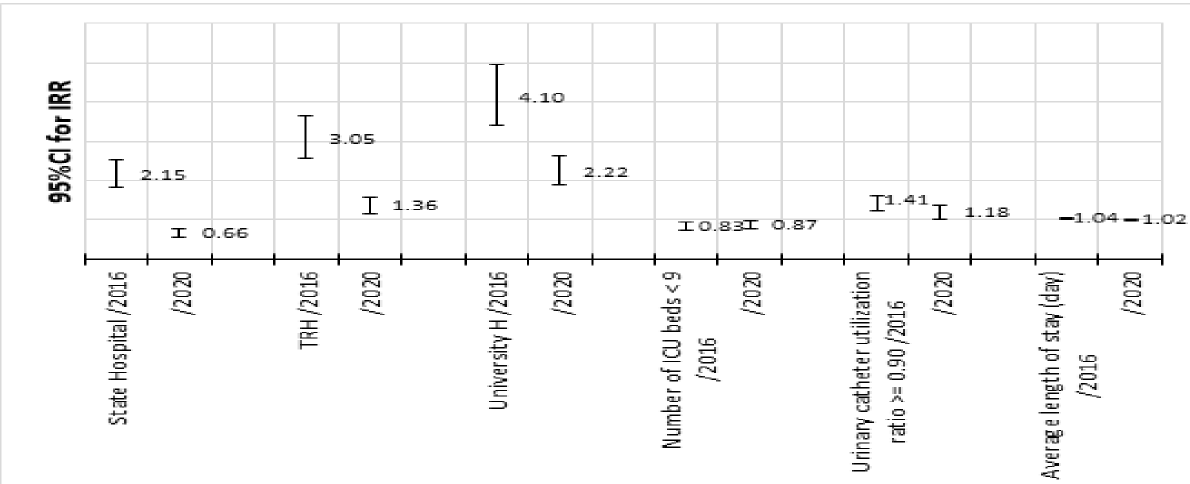
The CAUTI Model

In the CAUTI model, all variables were statistically significant like in the national model (Table 4). While the IRRs between the two models were different for all categories of hospital type, they were similar for other variables (Figure 3). The state hospital was a risk factor in the national model, but it was determined as a protective factor in this study.

Table 4. The negative binomial model for catheter-associated urinary tract infection.

Parameter	Beta	Standart Error	p value	IRR	95%CI for IRR
Intercept	-7.566	0.0922	<0.0001	0.0005	0.0004-0.0006
State Hospital	-0.407	0.0813	<0.0001	0.6660	0.5679-0.7810
TRH	0.304	0.0760	0.0001	1.3554	1.1679-1.5731
University Hospital	0.797	0.0845	<0.0001	2.2182	1.8794.2.6179
Private Hospital	Reference			1.0000	-
Number of ICU beds <9	-0.139	0.0610	0.0228	.8703	0.7722-0.9809
Number of ICU beds >=9	Reference			1.0000	-
Catheter utilization ratio >=0.90	0.168	0.0701	0.0163	1.1834	1.0315-1.3576
Catheter utilization ratio <0.90	Reference			1.0000	-
Average length of stay (day)	0.022	0.0040	<0.0001	1.0223	1.0143-1.0304

Dependent Variable: Number of CAUTIs; offset = Ln (catheter line-days)
CI: Confidence interval; IRR: Incidence rate ratio; TRH: Training and research hospital.



CI: Confidence interval; IRR: Incidence rate ratio; TRH: Training and research hospital.
Figure 3. Incidence rate ratios with 95% confidence intervals in the 2016 and 2020 catheter-associated urinary tract infection model.

DISCUSSION

We observed that all variables in the existing national models based on 2016 data remained statistically significant when repeated in models with the data of 2020 in this study. In addition, the intercepts in the models were very similar to their previous counterparts. While the reference category of the hospital type variable was private hospital in the national VAP and CAUTI models, it was state hospital in the new models in our study. The risk for CAUTI was significantly lower in all hospital types compared to the national model.

When looked at the current models developed by the Centers for Disease Control and Prevention (CDC), the parameter estimations and their standard errors were similar to our new models as well as our national models. The CDC models and our new models contain similar variables with some differences. In our models there was no data for wards and neonatal ICUs. There were also some differences in the categories of some variables such as ICU type and the number of hospital beds.[12]

The SIR is used as the primary summary measure in HAI surveillance instead of infection rates. It is more useful to monitor the changing in HAIs over time at national, regional, institutional or unit level. The crude SIR does not include more information than the ratio of infection rates unless it is calculated as stratified. However, the stratified SIR provides us additional information about the stratification variable or variables. When the denominator of the SIR, called predicted infection number, is obtained by multivariate analysis, the effects of many factors which are related to the development of infection can be taken into account simultaneously and it is called the adjusted SIR.[12-14] The use of CLABSI and CAUTI rates in Turkey, as in many countries, was a habit. On the other hand, the use of adjusted SIR and CAD, which gives more information than the rates was increasingly accepted by the ICCs in Turkey. However, the formulas used to calculate the predicted number of infections may need to be updated to provide accurate and up-to-date information for the SIR. As the infection control measures improve over time, the effect of variables such as hospital type, number of beds, average length of stay may also change in time.

The published reports show that the rates of invasive device-associated infections in ICUs are decreasing year by year in Turkey. This reduction trend is more pronounced in VAP and CAUTI than CLABSI. The same trend was observed in all types of hospitals, in all geographical regions, in hospitals with a bed capacity of 200 or more and less than 200. In the models in our study, it is not surprising that state hospitals are the least risky category instead of private hospitals among hospital types. Also, the SIRs obtained with the existing national models for CAUTI and VAP show that the decrease in state hospitals is serious, on the contrary, the number of VAP and CAUTI in private hospitals are higher than predicted in 2020. However, there is no similar situation for CLABSI.[4-8]

The results obtained in this study may have been particularly affected by the case finding and surveillance capacity of the hospitals. Nevertheless, these differences are not expected to be much more from 2016. There has been a change in the types of some hospitals compared to 2016, but this is not a limitation as it would cause the same change in terms of risk. In 2016, if there was more than a type of ICU in the same hospital, it was counted as a single ICU by combining the data. However, this limitation is not a question for the data of 2020. As the surveillance experience of the hospitals was increasing day by day, the results were obtained in this study may be more reliable.

CONCLUSION

As a result, we determined that the risk factors for invasive device-associated infections in ICUs in Turkey were similar between in 2016 and 2020. Although the IRRs were similar for most of the risk factors, the size of the risk for some of them changed significantly. Therefore, it is necessary to update the coefficients used in the calculation of the predicted infection numbers in the SIR formula, especially for VAP and CAUTI. Thus, it would be possible to provide more meaningful inferences with SIR and CAD.

ETHICAL DECLARATION

Since the study was conducted retrospectively with the existing data of the National HAI Surveillance which is carried out by the Ministry of Health, an ethics committee was not obtained but permission for the use of the data was obtained from the Ministry of Health

FINANCIAL SUPPORT No funding was received for this study.

CONFLICT OF INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

AUTHOR CONTRIBUTION

CHH, SS, EB, EYG, DA: conception and design of the paper

CHH, GP, MC, FK: data collection, analysis and interpretation

CHH, SS: draft manuscript

EB, EYG, DA, GP, MC, FK: critical revision of the article

CHH, SS, EB, EYG, DA, GP, MC, FK: final approval of the version intended for publication

REFERENCES

1. Infection Control Regulation of Inpatient Treatment Institutions. Official Gazette (Issue: 25903). (In Turkish).

2. Turkish General Directorate of Public Health. The national healthcare-associated infections surveillance standards 2017. (In Turkish) Available at: https://hsgm.saglik.gov.tr/depo/birimler/Bulasici-hastaliklar-db/hastaliklar/SHIE/Klavuzlar/Ulusal_Saglik_Hizmeti_Iliskili_Enfeksiyonlar_Surveyans_Standartlari_2017.pdf

3. Turkish General Directorate of Public Health. The national healthcare-associated infections surveillance guideline 2017. (In Turkish) Available at: https://hsgm.saglik.gov.tr/depo/birimler/Bulasici-hastaliklar-db/hastaliklar/SHIE/Klavuzlar/Ulusal_Saglik_Hizmeti_Iliskili_Enfeksiyonlar_Surveyans_Rehber Versiyon_1.pdf

4. Hekimoglu CH , Alp Mese E . The adjusted standardized infection ratio and cumulative attributable difference for central line-associated bloodstream infections and catheter-associated urinary tract infections in 2017, in Turkey. J Immunol Clin Microbiol 2020;5(1): 41-49.

5. Gozel MG, Hekimoglu CH, Gozel EY, Batir E, McLaws ML, Alp Mese E. National Infection Control Program in Turkey: The healthcare associated infection rate experiences over 10 years. Am J Infect Control 2021;49(7):885-892.

6. Refik Saydam Hygiene Center Presidency. The national nosocomial infections surveillance network (UHESA) report, Summary data, 2008-2009. (In Turkish) Available at: https://hsgm.saglik.gov.tr/depo/birimler/Bulasici-hastaliklar-db/hastaliklar/SHIE/Raporlar/UHESA_Ozet_Raporu_2008_-_2009.pdf

7. Turkish General Directorate of Public Health. The summary report of standardized infection ratio and cumulative attributable difference for invasive device-associated infections in intensive care units in Turkey, 2016. (In Turkish) Available at: https://hsgm.saglik.gov.tr/depo/birimler/Bulasici-hastaliklar-db/hastaliklar/SHIE/Raporlar/Standardize_Enfeksiyon_Orani_SIR_ve_Kumulatif_Atfedilebilir_Fark_CAD_Raporu_2016.pdf

8. Turkish General Directorate of Public Health. The summary report of standardized utilization ratio in intensive care units in Turkey, 2017. (In Turkish) Available at: https://hsgm.saglik.gov.tr/depo/birimler/Bulasici-hastaliklar-db/hastaliklar/SHIE/Raporlar/Standardize_Arac_Kullanim_Orani_SAKO_Raporu_2017.pdf

9. Hacimustafaoglu M. Standardized infection ratio (SIR). J Pediatr Inf 2019;13(2):121-123. (In Turkish)

10. Kaya Kalem A, Guner R, Kayaaslan B, Hasanoğlu I. Invasive Device-related Infections and Standardized Infection Ratios in an Training and Research Hospital Intensive Care Units. Flora 2020; 25(2):228-235. (In Turkish)

11. Sonmez A, Ozturk S, Abacigil F. Health Care Related Infection Epidemiology and Surveillance. Journal of Nursing Science. 2021;4(1):41-45. (In Turkish)

12. Centres for Disease Control and Prevention. The NHSN Standardized Infection Ratio (SIR): A Guide to the SIR. Available at: https://www.cdc.gov/nhsn/pdfs/ps-analysis-resources/nhsn-sir-guide.pdf

13. Centers for Disease Control and Prevention. Your guide to the standardized infection ratio (SIR). NHSN e-news: SIRs Special Edition. 2010:1-14.

14. Rioux C, Grandbastien B, Astagneau P. The standardized incidence ratio as a reliable tool for surgical site infection surveillance. Infect Control Hosp Epidemiol 2006;27:817-824.