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Indirect vs. direct standardization methods for reporting healthcare-associated infections: An analysis of central line-associated bloodstream infections in Maryland

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Abstract

Controversy exists as to whether healthcare-associated infection data should be presented using indirect (current CMS/CDC methodology) or direct standardization. We applied both methods to central line-associated bloodstream infection data from 45 acute-care hospitals in Maryland from 2012–2014. We found that the two methods generate different hospital rankings with payment implications.

Introduction

Consumer demand for information, including data about healthcare-associated infections (HAIs), has increased over the past decade. Publicly available websites, such as the Centers for Medicare and Medicaid Services (CMS) Hospital Compare,¹ present standardized incidence ratios (SIRs) using indirect standardization for evaluation of HAIs and other metrics of hospital quality. Some argue that indirect standardization is sub-optimal for inter-hospital comparison² because it fails to account for case-mix and may be distorted by variations in population numbers² and that direct standardization should be used for comparing hospitals (especially when ranking hospitals).³ Others argue that direct standardization is inappropriate for inter-hospital comparisons due to the small outcome frequency.⁴ Therefore, there is no consensus on whether indirect or direct standardization is preferable for HAI risk-adjustment, and the best approach for standardizing and presenting HAI data remains controversial.^{2,3,4,5} In addition to better understanding of the proper epidemiologic uses, an evaluation of the practical implications of each method is needed. Specifically, in the era of financial penalties based on HAI rate-based “ranks”, the impact of using each method on the resulting hospital ranking is unknown.

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The objective of this study was to assess whether employing direct standardization instead of indirect standardization changed hospitals' ranks for one HAI.

Methods

We examined publicly reported central line-associated bloodstream infection (CLABSI) data from all intensive care units (ICU) in 45 acute-care hospitals in the state of Maryland, USA from 2012–2014. Only hospitals that reported at least one CLABSI per year were included in the analysis (n=29 in 2012, n=28 in 2013 and n=28 in 2014). For each year, we ranked hospitals' CLABSI performance by both methods and compared changes between the rankings.

SIRs for CLABSI using indirect standardization were calculated as posted on Hospital Compare by comparing the reported number of CLABSIs with the predicted number of CLABSIs based on 2006–2008 National Safety Network (NHSN) data for each hospital.⁶ More specifically, the individual hospital provided the central line-days (CLD) (the weights) and the NHSN standard population provided the ICU-specific CLABSI rates based on the national experience.

For direct standardization, the individual hospitals provided the CLABSI rates and the standard population provided the standard central line-days by type of ICU (the weights).⁷ Standard population estimates and central line-days by type of ICU were obtained from the 2006–2008 NHSN report.⁸ For each hospital, we multiplied the observed ICU-specific CLABSI rate for each unit by the standard central line-days, then summed these values across the hospital. We divided this data by the sum of the standard central line-days in each unit. In summary, to generate the indirectly-standardized rate, we used CLD (weights) from the individual Maryland acute-care hospitals (study population) and the CLABSI rates from the NHSN data (standard population). To generate the directly-standardized rate, we used the CLABSI rates from the individual Maryland acute-care hospitals (study population) and CLD (weights) from the NHSN data (standard population).

Hospitals were ranked from lowest (best performing) to highest SIR (worst performing) using both indirect and direct standardization. The changes between ranks derived from both methods were used to generate slopegraphs for each year to assess differences between rankings. We also evaluated shifts in the observed quartile for each hospital based on the ranks derived from each method, with particular interest in the composition of hospitals with highest CLABSI rates in the bottom quartile.

$$\text{Indirect standardization} = \frac{\sum [\text{ICU-specific observed \#CLABSI}]}{\sum [\text{Standard ICU CLABSI rate} \times \text{Individual hospital ICU-specific CLD}]}$$

$$\text{Direct standardization} = \frac{\sum [\text{Individual ICU-specific CLABSI rate} \times \text{Standard CLD}]}{\sum [\text{Standard CLD}]}$$

Results

Table 1 shows the value and associated rank using indirect and direct standardization along with the reported number of CLABSI for each hospital for each study year. In 2012 and 2013 only 6/29 (21%) and 6/28 (21%) hospitals reported 5 or more CLABSI. In 2014, only 5/28 hospitals (18%) reported 5 or more CLABSI. The direction and magnitude of the change in rank between indirect vs. direct standardization varied. As indicated by the thick lines in Figure 1, ten (34.5%) hospitals' rank changed by 3 or more in 2012; 7 (25%) hospitals' rank changed by 3 or more in 2013 and; 10 (36%) hospitals' rank changed by 3 or more in 2014. Six hospitals (21%) changed quartiles in 2012 when direct standardization was employed instead of indirect standardization. Similarly, 6 hospitals (21%) changed quartiles in 2013 and 2014. In 2012, two hospitals moved from the 3rd quartile to the 4th quartile and two hospitals moved from the 4th quartile to the 3rd quartile. In 2013, one hospital moved into the 4th quartile and one moved out of the 4th quartile. In 2014, one hospital moved out of the 4th quartile and one moved into the 4th quartile.

Discussion

When direct standardization methods were utilized for adjusting CLABSI rates of Maryland hospitals instead of indirect methods (as currently used by CMS), many hospitals moved 3 or more rank positions in all study years. Moving from one quartile to another also occurred frequently. In all study years, some hospitals moved in and out of the 4th quartile. This is particularly noteworthy since hospitals in the 4th quartile are subjected to financial penalties for poor performance.

There are major limitations associated with both standardization methods. Comparison of hospitals using indirect standardization is not recommended^{2,3,5} because each hospital's indirectly standardized ratio is based on its own set of weights i.e., central line utilization. The critics of indirect standardization argue that the CLABSI SIRs for each hospital should therefore only be compared to the NHSN US benchmark rates (the standard population).⁸ In addition to the methodological complexities and limitations associated with indirect standardization, many consumers do not understand how to correctly interpret SIRs.⁹ However, indirect standardization metrics are frequently used to make inter-hospital comparisons, including when hospitals are ranked for reimbursement. Direct standardization methods are appropriate to use for the comparison of rates in two or more groups; however, this approach suffers from instability¹⁰ and is highly susceptible to random variation when dealing with small numbers (less than 20)⁴ as is the case with reported CLABSI in most Maryland hospitals.

In spite of the ongoing controversy surrounding HAI metrics, CMS recently began cutting payments to hospitals in the worst-performing quartile based on indirect standardization on risk-adjusted quality measures including CLABSI. Considering these financial repercussions, it is even more critical that the methods used to generate HAI metrics, and how this information is presented to the public, are carefully considered. Inter-hospital comparisons, made by the public when utilizing tools such as Hospital Compare, and for the purposes of reimbursement, are meaningless if risk adjustment for CLABSI and other HAIs

is not done correctly. Moreover, the number of CLABSI reported at most hospitals in Maryland was very small. A metric with such infrequent events may not paint a comprehensive picture of institutional performance and the appropriateness of continuing to use CLABSI as a hospital quality metric should be carefully considered.

This example using Maryland CLABSI data confirms that indirect and direct standardization methods generate different results with payment implications. Each method has its own limitations and the evidence presented here is not strong enough to promote a change in methods. However, both methods standardize CLABSI rates only by type of ICU making them prone to residual confounding illustrating the need for improved risk adjustment for specific HAIs. When publicly reporting HAI data, and when selecting metrics for value-based purchasing, standardized data should be presented and interpreted with caution.

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Figure 1.
Direction and magnitude of Maryland CLABSI rank change by standardization method (2012–2014)

*Hospital 1=lowest CLABSI rate=best performance

**Hospital numbers do not carry over between years (i.e. Hospital 1 in 2012 is not necessarily Hospital 1 in 2013 or 2014)

Table 1

Maryland CLABSI rates by standardization method and year

2012										2013										2014									
Indirect Standardization			Direct Standardization			# of CLABSI			# of CLABSI	Indirect Standardization			Direct Standardization			# of CLABSI			# of CLABSI	Indirect Standardization			Direct Standardization						
Rank	Value	Rank	Value	Rank	Value	Rank	Value	Rank		Value	Rank	Value	Rank	Value	Rank	Value	Rank	Value		Rank	Value	Rank	Value	Rank	Value				
1	0.11	1	0.16	1	0.16	1	1	1	1	1	0.16	1	0.18	1	0.13	1	1	1	1	1	0.13	1	0.25	1	1				
2	0.15	3	0.23	3	0.17	1	2	2	1	2	0.17	2	0.26	2	0.18	2	2	2	2	2	0.18	2	0.27	2	1				
3	0.15	2	0.17	1	0.28	1	3	3	2	3	0.28	3	0.31	3	0.18	3	3	3	3	3	0.18	3	0.29	3	2				
4	0.19	5	0.29	1	0.29	1	4	4	2	4	0.29	7	0.43	4	0.21	4	4	4	4	4	0.21	4	0.32	4	1				
5	0.20	4	0.26	1	0.29	1	5	5	2	5	0.29	4	0.34	5	0.22	5	5	5	5	5	0.22	5	0.33	5	1				
6	0.21	6	0.29	1	0.32	1	6	6	3	6	0.32	8	0.49	6	0.24	6	6	6	6	6	0.24	11	0.68	6	2				
7	0.26	7	0.32	2	0.34	2	7	7	2	7	0.34	6	0.42	7	0.27	7	7	7	7	7	0.27	8	0.55	7	2				
8	0.27	8	0.37	1	0.37	1	8	8	2	8	0.37	9	0.56	8	0.32	8	8	8	8	8	0.32	12	0.68	8	3				
9	0.32	9	0.48	1	0.38	1	9	9	6	9	0.38	5	0.41	9	0.33	9	9	9	9	9	0.33	7	0.49	9	1				
10	0.37	10	0.56	1	0.40	1	10	10	2	10	0.40	15	0.88	10	0.35	10	10	10	10	10	0.35	6	0.43	10	2				
11	0.42	13	0.72	3	0.42	3	11	11	1	11	0.42	10	0.63	11	0.38	11	11	11	11	11	0.38	9	0.57	11	2				
12	0.43	11	0.65	1	0.42	1	12	12	2	12	0.42	13	0.81	12	0.44	12	12	12	12	0.44	10	0.67	12	1					
13	0.43	20	1.22	22	0.44	22	13	13	1	13	0.44	12	0.66	13	0.46	13	13	13	13	0.46	13	0.69	13	1					
14	0.44	12	0.65	1	0.5	1	14	14	36	14	0.5	19	1.04	14	0.56	14	14	14	14	0.56	14	0.84	14	1					
15	0.46	15	1.01	6	0.56	6	15	15	3	15	0.56	14	0.84	15	0.58	15	15	15	15	0.58	18	1.06	15	35					
16	0.62	21	1.31	2	0.58	2	16	16	35	16	0.58	24	1.76	16	0.58	16	16	16	16	0.58	21	1.33	16	43					
17	0.64	14	0.95	10	0.61	10	17	17	1	17	0.61	16	0.91	17	0.64	17	17	17	17	0.64	15	0.97	17	2					
18	0.68	27	1.81	3	0.61	3	18	18	2	18	0.61	17	0.91	18	0.64	18	18	18	18	0.64	19	1.15	18	4					
19	0.68	24	1.61	47	0.63	47	19	19	4	19	0.63	20	1.28	19	0.68	19	19	19	19	0.68	16	1.02	19	3					
20	0.73	16	1.09	2	0.67	2	20	20	3	20	0.67	18	1.00	20	0.69	20	20	20	20	0.69	17	1.04	20	5					
21	0.73	17	1.10	1	0.71	1	21	21	10	21	0.71	21	1.63	21	0.81	21	21	21	21	0.81	24	1.70	21	2					
22	0.75	18	1.13	4	0.74	4	22	22	9	22	0.74	27	2.34	22	0.81	22	22	22	22	0.81	27	3.71	22	2					
23	0.77	19	1.15	3	0.75	3	23	23	4	23	0.75	11	0.65	23	0.85	23	23	23	23	0.85	20	1.27	23	10					
24	0.90	22	1.36	3	1.12	3	24	24	1	24	1.12	22	1.68	24	0.88	24	24	24	24	0.88	23	1.67	24	4					
25	1.11	25	1.67	1	1.13	1	25	25	2	25	1.13	23	1.70	25	0.91	25	25	25	25	0.91	26	2.07	25	12					

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2014											
Indirect Standardization			Direct Standardization			# of CLABSI			Indirect Standardization		
Rank	Value	Rank	Value	Rank	Value	Rank	Value	Rank	Value	Rank	Value
26	1.17	26	1.76	8	1.33	26	1.33	25	1.99	5	1.09
27	1.36	23	1.43	17	1.34	27	1.34	26	2.01	2	1.37
28	1.49	28	2.23	2	2.06	28	2.06	28	3.10	1	2.86
29	1.52	29	2.28	3						28	4.30