Healthcare-associated infection prevention and control management in a tertiary hospital and an overall evaluation

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Background: Healthcare-associated infection (HAI) is a crucial factor influencing medical quality. Studies about HAI management situations are rare, especially for the Inner Mongolia region of China. Therefore, this study aimed to investigate management procedures and the overall evaluation of HAI in order to inform HAI management improvement more scientifically.

Methods: A questionnaire was used to investigate HAI-related prevention and control indicators in tertiary hospitals in the Inner Mongolia region from July 2018 to June 2019.

Results: The survey showed that the mean incidence rate of HAI was 3.79%. The mean rate of hand hygiene compliance of healthcare workers (HCWs), inpatient's antibiotics-use rate, and the detection of the antibiotic ratio before therapy was 54.34%, 34.33%, and 25.40%, respectively. The mean of the surgical site infection (SSI) rate of the level I incision and the preventive antibiotics-use ratio of the level I incision was 1.31% and 28.89%, respectively. The mean of the multi-drug resistant organism (MDRO) infection rate was 0.40% and the mean of the MDRO detection rate was 18.55%. The mean of the central line-associated bloodstream infection rate was 2.24%, the ventilator-associated pneumonia (VAP) rate was 11.17%, and the catheter-associated urinary tract infection (CAUTI) rate was 1.95‰. As for the overall evaluation, 19 (35.85%) hospitals had a bad grade, 18 (33.96%) hospitals had a medium grade, and 16 (30.19%) hospitals had a good grade.

Conclusions: The incidence rate of HAI in tertiary hospitals in the Inner Mongolia region is higher than the national level. Also, the overall evaluation of bad-grade hospitals and their deficiencies should be used as an example to improve the HAI management level.

Keywords: Healthcare-associated infection management (HAI management); healthcare-associated infection quality control indicator (HAI quality control indicator); healthcare-associated infection prevention and control (HAI prevention and control); overall evaluation

Introduction

Healthcare-associated infection (HAI) is a threat to inpatient's medical safety and can negatively affect the medical quality of hospitals. More attention has been paid to HAI management, and an independent HAI management department has been established in most healthcare facilities in order to control HAI. Since HAI management in China began later than in developed countries, several problems, including management instability, surveillance incompleteness, and healthcare workers' (HCWs) low awareness of HAI, remain unresolved (1-6). Inner Mongolia is a considered a developing region in northern China. Understanding the current status and identifying the weak links in HAI management within Inner Mongolia could improve HAI management and decrease the incidence rate of HAI, shorten the average length of stay (LOS), improve the circulation speed of medical facilities, reduce the economic burden of patients, and promote the hospital's social and economic influence. Despite this need, little research concerning HAI management is available, especially related to the Inner Mongolia region (7-19). In order to understand the HAI management situation, we conducted a survey of 11 indicators as outlined by the National Health Commission's HAI management requirements, considered to comprehensively reflect the HAI management situation. This survey included 53 tertiary hospitals in 12 cities, covering all cities in Inner Mongolia. Rank-sum ratio (RSR) was used to evaluate HAI management situation overall.

Methods

Sampling method

The sample included all the tertiary hospitals in the Inner Mongolia Autonomous Region, with a total of 53 hospitals in 12 cities. Each city had at least 1 tertiary hospital. The 53 hospitals covered all areas in the Inner Mongolia Autonomous Region, which is in northern China. The study was approved by the Ethics Board of Inner Mongolia People's Hospital (No. 202000303L).

Survey

According to HAI the management quality control indicator section in the *National Health Commission's notification of quality control indicator of anesthesiology and other six majors* (20), 11 indicators were selected as an evaluation of HAI prevention and control effect including the incidence rate of HAI, multi-drug resistant organism (MDRO) infection rate, MDRO detection rate, hand hygiene compliance of HCW, inpatients' antibiotics-use rate, antibiotics detection ratio before therapy, surgical site infection (SSI) rate of the level I incision, the preventive antibiotics-use ratio of the level I incision, central line-associated bloodstream infection rate, ventilator-associated pneumonia (VAP) rate, and catheter-associated urinary tract infection (CAUTI) rate.

Definitions

HAI was defined as an infection present at the time of hospital admission or within 48 hours of admission.

Indicators to assess the HAI situation were defined according the formulas given below:

❖ Incidence rate of HAI = existing HAI case number/ total inpatient number in the same period ×100%;

❖ MDRO infection rate = MDRO infection case number/ total inpatient number in the same period ×100%;

❖ MDRO detection rate = strain number of MDRO detection number/strain number of the same organism detection number ×100%;

❖ Hand hygiene compliance of HCW = number of times hand hygiene was performed/number of times hand hygiene was investigated ×100%;

❖ Inpatients' antibiotics-use rate = number of antibiotics used by an inpatient/total inpatient number in the same period ×100%;

❖ Antibiotics detection ratio before the therapy = case number of antibiotics detected before therapy/total number of antibiotics used by inpatients in the same period ×100%;

❖ SSI rate of the level I incision = case number of SSI rate of the level I incision/total patient number of the patient level I incision ×100%;

❖ The preventive antibiotics-use ratio of the level I incision = patient number of the preventive antibiotics-used ratio of the level I incision/total patient number of the patient level I incision ×100%;

❖ Central line-associated bloodstream infection (CLABSI) rate = case number of CLABSI/total days that the central line was used ×100%;

❖ VAP rate = case number of VAP/total days that the ventilator was used ×100%;

❖ CAUTI rate = case number of CAUTI/total days that the catheter was used ×100%.

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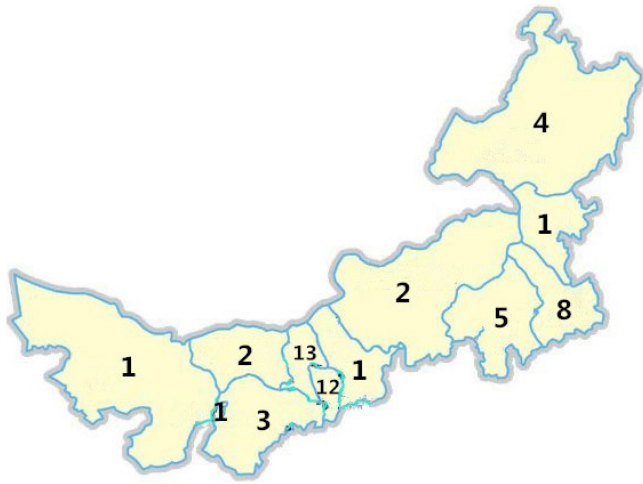
Figure 1 Distribution of hospitals surveyed.

Table 1 Characteristic of hospitals surveyed

Hospital classification	Number	%
Hospital level		
Provincial hospital	6	11.32
Municipal hospital	47	88.68
Teaching hospital		
Yes	42	79.25
No	11	20.75
Hospital type		
General hospital	34	64.15
Specialized hospital	10	18.87
Tradition Chinese or traditional Mongolian	9	16.98
Total	53	100.00

RSR calculation

Probability unit *Probit* was used to express the distribution of RSR, which is the total downward accumulative frequency of the given RSR values. The protocol for the calculation of *Probit* is as follows: (I) design a RSR frequency distribution table, list the frequency (*f*) of different groups, and calculate the accumulative total frequency ($\sum f$) of a given group; (II) calculate the rank (*R*) and average rank (*AR*) of the RSR of a given group; (III) calculate the downward accumulative total frequency (*p*=AR/n), and switch the percentage (*p*) to the frequency unit *Probit*. *Probit* should correspond with the standard normal deviation (*u*) of the percentage (*p*) plus 5.

Data organization and analysis

EpiData3.0 was used to build the database, Microsoft Excel 2010 was used to organize the data, SPSS 19.0 was used for the data analysis, and a P value <0.05 was considered as statistically significant.

Non-parametric RSR was used to conduct an overall evaluation of HAI prevention and control quality, and RSR was used to summarize the overall level of several indicators.

Results

Distribution and characteristic of hospitals

A total of 53 hospitals, covering all cities in the Inner Mongolia Autonomous Region, were included in the analysis, with the distributional number being shown in *Figure 1*. Most of the hospitals in this study were municipal hospitals (88.68%), teaching hospitals (79.25%), and general hospitals (54.15%) (*Table 1*).

HAI management quality control indicator

The survey showed that the highest, lowest, and average incidence rate of HAI was 5.03%, 3.02%, and 3.79%, respectively. The mean of hand hygiene compliance of HCW, inpatients' antibiotics-use rate, and antibiotics detection ratio before therapy were 56.34%, 34.33%, and 25.40%, respectively. The mean SSI rate of the level I incision was 1.31%, and the preventive antibiotics-use ratio of the level I incision was 28.89%. The mean of MDRO infection rate was 0.40%, and the mean of MDRO detection rate was 18.55%. The mean rate of the central line-associated bloodstream infection was 2.24‰, the VAP was 11.17‰, and the CAUTI was 1.95‰. These details are shown in *Table 2*.

Overall evaluation of HAI prevention and control quality

Indicators and RSR

Among the 11 indicators, hand hygiene compliance of HCW (Y4) and antibiotics detection ratio before therapy (Y6) were ranked from low to high. Other indicators including incidence rate of HAI (Y1), MDRO infection rate (Y2), MDRO detection rate (Y3), inpatients' antibiotics-use rate (Y5), SSI rate of the level I incision (Y7), the preventive

Table 2 Indicator distribution

Quality control indicator	Mean ± SD	Maximum	Minimum
Incidence rate of HAI	0.038±0.005	0.050	0.030
MDRO infection rate	0.004±0.001	0.006	0.002
MDRO detection rate	0.186±0.019	0.220	0.149
Hand hygiene compliance of HCW	0.563±0.053	0.658	0.481
Antibiotics use rate of inpatient	0.343±0.028	0.417	0.302
Antibiotics detect ratio before therapy	0.254±0.030	0.309	0.201
SSI rate of level incision	0.013±0.002	0.016	0.010
Preventive antibiotics use ratio of level I incision	0.289±0.005	0.299	0.280
Central line associated blood stream infection rate	0.022±0.001	0.025	0.020
Ventilator associated pneumonia rate	0.112±0.012	0.143	0.090
CAUTI rate	0.019±0.001	0.021	0.018

HAI, healthcare-associated infection; MDRO, multi-drug resistant organism; HCW, healthcare worker; SSI, surgical site infection; CAUTI, catheter-associated urinary tract infection.

antibiotics-use ratio of the level I incision (Y8), central line-associated bloodstream infection rate (Y9), VAP rate (Y10), and CAUTI rate (Y11) were ranked from high to low. The average rank value was used for the same indicator of the same value.

Calculations included RSR by a matrix of 11 indicators and rank hospitals by RSR values (*Table 3*).

Distribution of RSR

The distribution of RSR (probability unit *Probit*), average rank *AR*, and downward accumulative total frequency P was calculated based on the abovementioned method. The RSR values were between 0.223–0.801 and the *Probit* values were between 2.922–7.078. These details are shown in *Table 4*.

Regression equation

To calculate the regression equation, the accumulative total frequency corresponding probability unit, *Probit*, was used as the independent variable while RSR value was used as the dependent variable. The linear regression equation was as follows: RSR = A + B × *Probit*. According to the previous results of RSR and *Probit*, the regression equation was calculated as follows: RSR = –0.67482 + 0.23532 *Probit* (F=1425.68, P<0.001).

Grade and rank

Grade and rank evaluations were given according to the RSR value. In addition, the three-grade method was used in

this research; grade function and corresponding frequency unit cut-off values were based on medical biostatistics version 4 (Editor: Sun Zhenqiu). These details are shown in *Table 5*. After that, grade and rank evaluations were given according to the graded probability unit *Probit* value and the corresponding RSR estimated value based on the regression function calculation. The grade and rank results are shown in *Table 5*.

Discussion

The incidence rate of HAI was associated with scale, class, and the patient's situation in the hospital. The mean incidence rate of HAI from this survey was higher than both the national level (1.58%) and the result of a survey conducted in 184 tertiary hospitals in 2016 (21) that also had a result higher than 2.73% in Guizhou province (22). Furthermore, hand hygiene compliance of HCW, antibiotics detection ratio before therapy, the SSI rate of the level I incision, the preventive antibiotics-use ratio of the level I incision, MDRO infection rate, MDRO detection rate, and the VAP rate were lower than the rates found in other regions (23-26). The inpatients' antibiotics-use rate and the CAUTI rate was the same as the national level. Lastly, the central line-associated bloodstream infection rate was higher than the national level (27-29).

The incidence rate is a direct reflection of HAI management quality. The principle aim of HAI management

Table 3 Rank and the RSR of indicators

Hospital number	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Y11	RSR
1	45	48	44	51	44	51	49	53	42	50	50	0.903
2	38.5	45.5	38	45	35	52	51	46	47.5	49	41	0.838
3	33.5	17.5	25	52	37	32	19.5	51	29	44	34	0.642
4	37	45.5	39	36	39	53	52	49	46	28	38.5	0.794
5	42	23.5	13	49	36	34	28.5	44	21	33.5	37	0.620
6	31.5	52	41	41	45	50	50	48	39	48	50	0.850
7	22	17.5	35	4	17	33	17	37	16	16.5	27	0.415
8	25	37	5	42	25	47	23.5	21	29	13	19	0.491
9	27	31	21	27	33	36	37.5	31	8.5	14	30	0.508
10	20	15.5	31	10	14	30	19.5	39	36.5	21	10	0.422
11	35	40.5	37	47	29	31	23.5	28	31.5	24	27	0.606
12	22	32	6	22	46	35	37.5	35.5	18.5	33.5	30	0.545
13	4	2.5	1	2	2	2	1	1	4	3	13.5	0.062
14	15	7	28	11	10	27	21.5	11.5	23.5	4	24	0.313
15	17	5.5	23.5	21	38	26	25.5	34	14	15	27	0.423
16	43.5	50	45	38	43	49	48	27	47.5	46.5	44	0.826
17	16	40.5	15.5	39	31	29	31	33	44	8.5	24	0.534
18	5	2.5	9.5	18	4	24	28.5	15.5	36.5	38.5	24	0.353
19	33.5	49	42	44	47	48	53	39	40.5	25.5	50	0.809
20	11	8	18	7.5	13	25	21.5	7	23.5	30	13.5	0.305
21	51	52	53	46	53	45	46	32	52	52	47	0.907
22	28	30	23.5	40	34	28	34.5	23.5	7	5	30	0.486
23	8	5.5	3	1	1	5	3	4	1	2	34	0.116
24	18	11	36	28	19	18	27	51	29	31	16.5	0.488
25	40	20.5	30	23	30	20	17	9	8.5	19	10	0.389
26	31.5	52	48	34	50	42	47	39	50.5	45	47	0.834
27	38.5	37	27	20	21.5	23	37.5	18	12	7	34	0.473
28	3	10	2	3	8	4	4.5	5	2.5	1	5	0.082
29	52	44	43	43	32	44	37.5	35.5	35	46.5	47	0.788
30	13	2.5	19	24	20	19	17	14	21	42.5	2	0.333
31	24	2.5	32	33	7	21	8	19.5	10	16.5	10	0.315
32	11	20.5	14	50	6	22	25.5	10	16	10.5	6	0.328
33	46	47	46	53	27	46	42	47	49	22	44	0.804
34	30	15.5	8	9	21.5	16	12	17	34	6	34	0.348

Table 3 (*continued*)

Table 3 (continued)

Hospital number	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Y11	RSR
35	47	37	50.5	35	48	43	44	23.5	53	40.5	41	0.793
36	41	23.5	26	32	41	17	34.5	42.5	31.5	12	21.5	0.553
37	50	35	52	5	52	39	44	29.5	38	38.5	41	0.727
38	11	19	33	17	11	1	13	13	25.5	18	19	0.310
39	6	9	11.5	12	15	3	6	8	16	36	2	0.214
40	2	13	20	13	12	9	14.5	25	5.5	40.5	13.5	0.288
41	29	28.5	17	26	26	15	40.5	42.5	40.5	23	19	0.527
42	1	23.5	11.5	6	3	8	2	2.5	12	32	16.5	0.202
43	49	43	40	31	42	40	44	51	21	20	38.5	0.720
44	48	40.5	15.5	29	28	7	8	45	33	29	34	0.544
45	53	33.5	47	37	49	38	31	26	44	53	52.5	0.796
46	36	26.5	22	16	16	13	8	15.5	18.5	10.5	2	0.315
47	22	13	7	7.5	5	12	10.5	2.5	12	27	7	0.215
48	7	26.5	29	25	24	6	4.5	6	2.5	42.5	13.5	0.320
49	14	33.5	34	19	18	10	40.5	41	5.5	35	21.5	0.467
50	19	40.5	50.5	48	40	41	31	29.5	25.5	51	52.5	0.735
51	26	23.5	9.5	15	23	11	14.5	11.5	50.5	8.5	4	0.338
52	9	13	4	14	9	14	10.5	19.5	44	37	8	0.312
53	43.5	28.5	49	30	51	37	33	22	27	25.5	44	0.670

RSR, rank-sum ratio.

Table 4 distribution of RSR, AR, P and *Probit*

Item	Maximum	Median	Minimum
RSR	0.801	0.472	0.223
AR	53	27	1
P	1	0.509	0.019
Probit	7.078	5	2.922

RSR, rank-sum ratio; AR, average rank.

Table 5 Cut-off value of grade and rank

Type	Px	Probit	RSR	Hospital number
T1 (bad)	<15.866	<4	<0.353	19
T2 (medium)	15.866–84.134	4–6	0.353–0.642	18
T3 (good)	>84.134	>6	>0.642	16

RSR, rank-sum ratio.

is to reduce the incidence rate of HAI. Hand hygiene and rational antibiotic use are 2 crucial measures for preventing and controlling HAI (13,30). MDRO infection, SSI, VAP, CAUTI, and central line-associated bloodstream infection are several main infection types of HAI (31-33). The effective control rate of these infections results in the effective control of the incidence rate of HAI (8,34). Therefore, investigating 11 HAI management indicators could comprehensively reflect the HAI management situation, and evaluation based on these 11 HAI management indicators could provide an overall assessment of HAI management quality of a given hospital.

Medical care evaluation is an important method and type of evidence in hospital quality control. An overall evaluation can be completed by quantifying multiple factors of medical care quality and ranking these evaluation objects to provide evidence of medical judgment (35). Research

has shown that RSR is an overall evaluation method which has practical application, and it has been widely used in hospital quality evaluation (36). Using RSR to evaluate the overall evaluation has the advantage of not needing specific requirements of indicator and evaluation objects. RSR has no unit, and so rank calculation can eliminate interference of abnormal values (37). The present study is the first to use RSR for the overall evaluation off HAI management quality. Evaluating HAI management's using several quality indicators by RSR is simple, practicable, and objective. It is thus a scientifically sound method for effectively improving HAI management and can be used as an alternative evaluation tool for health administrations' assessment or selection.

Conclusions

This study included all tertiary hospitals in Inner Mongolia Autonomous Region, which has high quality medical care, in its survey. We chose 11 indicators with high importance, that we were confident could reflect HAI prevention and control quality; these indicators could comprehensively reflect HAI management quality overall, and its evaluation result has reference value. Our findings showed 19 (35.85%) hospitals had a bad grade, 18 (33.96%) hospitals had a medium grade, and 16 (30.19%) hospitals had a good grade. Hospitals with bad grades should enhance their management and improve their HAI prevention and control measures. Based on a survey of 11 HAI management indicators, Rank Sum Ration was used to overall evaluating the HAI management status of each hospital in the study. Overall evaluation based on Rank Sum Ration is a scientific evaluation tool of hospital HAI management quality assessment.

Since the current status of HAI management in Inner Mongolia has been seldom discussed, we endeavored to provide a comprehensive survey that included 11 HAI management indicators. From this we derived a greater understanding of the HAI management situation in Inner Mongolia. Based on this, the advantages and weaknesses of HAI management in Inner Mongolia could be further discussed in a future study which could provide scientific evidence to inform the improvement of HAI management in the region.

Acknowledgments

Footnote

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