Tzu Chi Medical Journal 2019; 31(3): 182–187

Original Article

Utilization of a central venous catheter insertion care bundle in Taiwan: A cross-sectional analysis of the National Health Insurance Research Database

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Received : 15-Mar-2018
Revised : 16-Apr-2018
Accepted : 03-Jul-2018

Abstract

Objectives: The objectives of this study are to explore medical care utilization associated with promoting the central venous catheter (CVC) care bundle plan using Taiwan's National Health Insurance Research Database (NHIRD). **Materials and Methods:** We performed a cross-sectional, secondary analysis of the data from patients who were admitted to a medical center for the first time between July 1, 2010, and June 30, 2012, in the NHIRD. The control group was patients who were admitted at nine medical center hospitals that participated in the pilot plan, and the study group was patients who were admitted at other ten medical center hospitals that did not participate in the pilot plan, and the differences between groups were analyzed. **Results:** After implementing the CVC care bundle, the average hospital stay decreased significantly (18.43 ± 12.96 vs. 15.49 ± 10.16, $P < 0.05$). In addition, the study group patients were clinically less likely to require antibiotics than the control group (odds ratio = 0.33, 95% confidence interval [CI] = [0.07, 1.71] vs. 0.62, 95% CI = [0.40, 0.96], $P = 3768$), and their medical expenses were lower (220, 618 ± 226, 419 vs. 208, 079 ± 193, 610, $P > 05$). Furthermore, the incidence rate of CVC-associated sepsis decreased from 12.59% to 5.66%. **Conclusions:** By implementing the CVC care bundle in clinical practice in accordance with national policies, medical utilization decreased, thereby considerably improving medical resource usage. These results confirmed that implementing the CVC care bundle possibly decreased medical utilization in clinical practice.

Keywords: *Central venous catheter-associated sepsis, Central venous catheter care bundle, National health insurance research database, Patients' length of stay, Use of medical resources*

Introduction

Central venous catheter (CVC)-associated sepsis is defined as bacteremia originating from an intravenous catheter. It is the main cause of hospital-acquired infection associated with morbidity, mortality, and increased costs. The increasing use of CVCs has led to problems that countries are beginning to address. According to a study by the American Medical Association, medical costs for CVC-associated sepsis have become the highest among those for related infections in all medical institutions. Because this problem can be prevented and because consumers expect superior services, insurance companies are unwilling to pay for the additional medical expenses incurred, thereby creating medical disputes [1]. Since January 1, 2011, the US Medicare and the Centers for Medicare and Medicaid Services mandated that all institutions report all blood infections in intensive care units as well as all infections in the hospital. Medicare will subsequently determine the benefit package provided depending on the "hospital-acquired infection rate" (a key performance indicator). The objective for the CVC care bundle is zero infections.

In 2009, the Infection Control Society of Taiwan introduced intervention measures for various catheter types. From June 1, 2011, to December 31, 2012, Taiwan's Centers for Disease Control and the Joint Commission of Taiwan initiated a national pilot plan in which 14 hospitals (nine medical center hospitals and five community hospitals) participated

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Access this article online
Quick Response Code:
Website: www.tcmjmed.com
DOI: 10.4103/tcmj.tcmj_63_18

How to cite this article: Chung HC, Wang LS, Wu JL, Hsieh TC. Utilization of a central venous catheter insertion care bundle in Taiwan: A cross-sectional analysis of the National Health Insurance Research Database. Tzu Chi Med J 2019;31(3):182-7.

in the promotion of the CVC care bundle, and there were five major interventions: optimal catheter site selection, hand hygiene, maximal sterile barrier precautions, chlorhexidine skin antisepsis, and control line maintenance bundle [2]. The goals were to reduce CVC-associated sepsis, assess the sustainability and cost-effectiveness of the pilot plan, and develop a model suitable for improving the quality of care in medical facilities in Taiwan [3]. There are few studies involving large-scale budget analyses of patients contracting infections in hospitals in Taiwan, most have estimated expenses in a single research institution [4]. The National Health Insurance (NHI) was officially implemented in 1995; currently, approximately 99.3% of the Taiwanese population pays into the NHI. In this study, the NHI Research Database (NHIRD) was used to investigate information on inpatients in medical centers who have undergone CVC placement, CVC usage trends, antibiotic use, and medical expenses. Differences between patients who underwent CVC placement and those who did not in terms of the aforementioned variables were analyzed to gain insight into the benefits of implementing intervention measures for CVC-associated sepsis. The results can serve as a reference when formulating NHI policies to facilitate optimal medical care.

Materials and methods

Study design

We performed a retrospective analysis of patients who were hospitalized for the first time from July 1, 2010, to June 30, 2012. Those who had incomplete personal information, or incomplete hospital arrival or departure information, or who had stayed in the hospital for more than 100 days, or who had visited a medical center both before and after July 1, 2011, were excluded from the study. The control group was patients admitted at nine medical center hospitals that participated in the pilot plan; the study group was patients admitted at other ten medical center hospitals that did not participate in the pilot plan. Predetected date was nonexposure CVC care bundle period between July 1, 2010, and June 30, 2011, and postdetected date was exposure CVC care bundle period between July 1, 2011, and June 30, 2012.

This study was approved by the Research Ethics Committee of Hualien Tzu Chi Hospital, Buddhist Tzu Chi Medical Foundation (Project No. IRB 103–116-C). Patients whose medical expenses order code among inpatient orders was 47015B were classified as those who had a CVC. Patients whose inpatient expenditures had admissions ICD-9 diagnosis codes of 038, 041.9, or 790.7 were classified as patients who had CVC sepsis. Patients with anatomical therapeutic chemical codes beginning with J01 were classified as those who had used antibiotics.

Data collection

The NHIRD contains all registration files and details of the original claims of 1 million beneficiaries from the NHI database and is used for research purposes. This database includes outpatient records, inpatient records, and medical care methods from 1996 to 2012. The ninth revision of the International Classification of Diseases (ICD-9-CM) was utilized to determine patient illnesses using these data. Order codes defined by the NHI Administration of the Ministry of Health and Welfare were used to identify medical treatments and medication usage records.

Statistical analysis

File analyses, related descriptions, and deductive statistics were used with SAS version 9.4 for Windows (SAS Institute, Inc., Cary, NC, USA). The average length of hospital stay, average medical expenses, CVC-associated sepsis rates, and antibiotics usage rates was compared between the study and control groups. Two sample *t*-tests and the Chi-squared test were used to compare differences between patients before and after implementing the pilot plan. In addition, multiple linear regression analysis and logistic regression analysis adjusted by age and gender were used to determine whether the time factor (i.e., before and after implementing the pilot plan) and the group factor (i.e., study group and control group) had an interaction effect on each other, and $P < 0.05$ indicates statistical significance.

Ethical approval

The study was conducted by the Declaration of Helsinki and was approved by the Local Ethics Committee of the institution. Informed written consent was waived because the study was a retrospective data analysis (IRB103–116-C).

Results

Descriptive analysis of inpatients who used central venous catheter

A database analysis showed that from July 1, 2010, to June 30, 2012, 13,363 patients were hospitalized for the first time at one of the medical centers. A total of 5% of medical center inpatients had a CVC inserted during hospitalization. The study group and control group comprised 5028 and 8334 patients, respectively. The study group's CVC usage rate decreased after the pilot plan was implemented (4.26% vs. 5.63%). By contrast, the control group's CVC usage increased after the pilot plan was implemented (5.19% vs. 5.08%). However, for both groups, the differences were not statistically significant [Figure 1].

Analysis revealed no difference in the number of male and female patients who used a CVC (a ratio of 1:1). There were also no significant differences in the age of the patients before and after implementation of the CVC bundle care plan, but there was a gender difference between predetected and postdetected date of bundle care plan periods in the group that used a CVC ($P = 0.002$) [Table 1].

Comparison of medical resource usage after using central venous catheter between groups

The average length of hospital stay for patients who used a CVC was significantly lower in the study group ([pre] 18.43 ± 12.96 vs. [post] 15.49 ± 10.16, $P = 0.046$) than the control group ([pre] 20.23 ± 14.15 vs. [post] 19.00 ± 13.94, $P = 0.36$). The medical expenses of inpatients who used a CVC were lower in the study group than the control group after implementing the pilot plan, respectively ([pre] 220,618 ± 226,419 vs. [post] 208,079 ± 193,610, $P = 0.64$), but the control group's medical expenses increased after the pilot

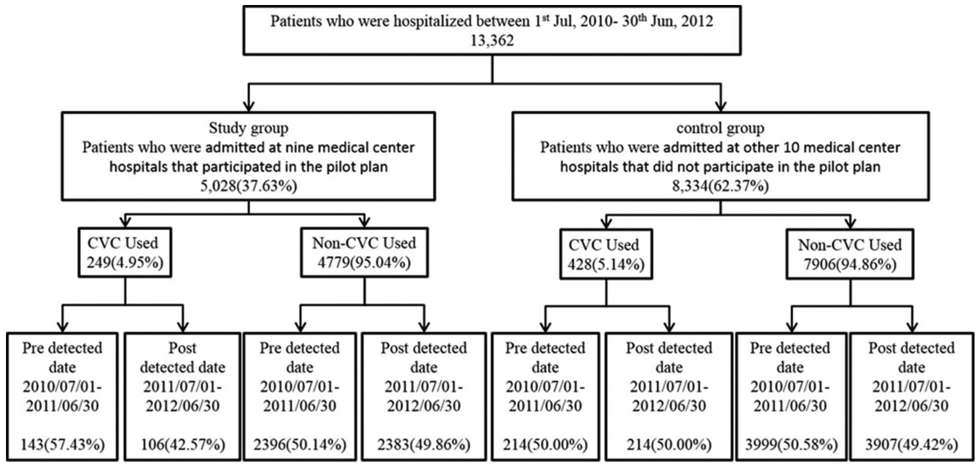

Figure 1: Data collection

plan were implemented ([pre] 22,5973 ± 205,031 vs. [post] 254,006 ± 292,549, *P* = 0.25).

The average length of hospital stay of all patients was not different ([pre]7.49 ± 7.516 vs. [post] 7.22 ± 7.57, *P* = 0.20) than in the control group ([pre]7.27 ± 8.30 vs. [post] 7.06 ± 6.86, *P* = 0.21). The medical expenses of the study group decreased after implementing the pilot plan ([pre] 56,182.5 ± 83,827.4 vs. [post] 52,932.2 ± 71510.7, *P* = 0.14) but increased for the control group ([pre] 52328.5 ± 76040.1 vs. [post] 54882.3 ± 94475.0, *P* = 0.17) [Table 2].

Comparison of central venous catheter-associated sepsis rate between groups

After the pilot plan was implemented, the CVC-associated sepsis rate slightly decreased in the study group (113 [4.45%] vs. 80 [3.21%], odds ratio [OR] = 0.71, 95% confidence interval [CI] = [0.53, 0.96]), and also in the control group (68 [1.60%] vs. 32 [0.77%], OR = 0.48, 95% CI = [0.31, 0.73]). For inpatients who used CVC, the CVC-associated sepsis rate decreased after the pilot plan was implemented for both the study group and control group (18 [12.59%] vs. 6 [5.66%], OR = 0.42, 95% CI = [0.16, 1.09] and 38 [22.49%] vs. 26 [17.69%], OR = 0.74, 95% CI = [0.43, 1.29], respectively). However, no significant differences were observed between the two groups [Table 3].

Comparison of antibiotics usage after using central venous catheter between groups

The antibiotics usage rate slightly decreased after the pilot plan was implemented in the study group (1788 [70.42%] vs. 1740 [69.91%], OR = 0.98, 95% CI = [0.87, 1.10]) as well as the control group a (333 [7.84%] vs. 287 [6.91%], OR = 0.87, 95% CI = [0.74, 1.03]). For inpatients who did not use CVC, there was no difference in the antibiotics usage rate after implementing the pilot plan between the study group and control group (1647 [68.74%] vs. 1639 [68.78%], OR = 1.00, 95% CI = [0.89, 1.13] and 167 [4.09%] vs. 141 [3.52%], OR = 0.86, 95% CI = [0.68, 1.08], *P* = 0.965). For those who used CVC, this rate slightly decreased after the pilot plan was implemented in the study group and control group (141 [98.60%] vs. 101 [95.25%], OR = 0.33, 95% CI = [0.07, 1.71] and 166 [77.6%] vs. 146 [68.2%], OR = 0.62, 95% CI = [0.40, 0.96], respectively). These results indicate that the antibiotic usage rate was clinically different between the study and control groups (*P* = 0.3768) after the pilot plan was implemented [Table 4].

Discussion

In this study, the NHIRD data of 13,363 patients who were hospitalized in a medical center for the first time between July 1, 2010, and June 30, 2012 were analyzed. Approximately 4.26%–5.63% of the inpatients used a CVC. After the CVC care bundle was implemented, the CVC usage rate (5.63% vs. 4.26%, *P* > 0.05), average length of stay (18.43 ± 12.96 vs. 15.49 ± 10.16, *P* < 0.05), medical expenses (220,618 ± 226,419 vs. 208,079 ± 193,610, *P* > 0.05), catheter-related bloodstream infection (CRBSI) rate (18 [12.59%] vs. 6 [5.66%], OR = 0.42, 95% CI = [0.16, 1.09]), and antibiotics usage rate (141 [98.60%] vs. 101 [95.25%], OR = 0.29, 95% CI= [0.06, 1.51]) all decreased compared with the period before the bundle care plan. However, only the average length of stay exhibited a significant decrease (*P* = 0.046). All indicators were lower in the study group than in the control group; however, no significant differences between groups were observed.

In March 2008, the Agency for Healthcare Research and Quality announced several patient safety strategies. The use of the care bundle to lower the probability of CRBSI was among the top ten most strongly supported strategies, indicating the amount of attention paid to this concern [5-10]. Medical resource usage-related indicators revealed that for institutions that employed the CVC care bundle, the average length of hospitalization decreased considerably from 18 days to 15 days. The medical costs for CVC-associated sepsis decreased by NT$5,787,552, which was considerably higher than the decrease facilitated by other infection control measures, for which decreases ranged from NT$155,680 to NT$523,264. These findings were similar to other studies [11-13].

We considered when patient developing BSI after CVC insertion, length of stay, and total costs was associated with longer hospital stay (+7 days) and an additional $129,000 in

Table 1: Gender and age distribution of patients

Patient treatment	Detected date of bundle care plan	Study group (n=5028) Total	Gender Female, n (%)	Gender Male, n (%)	P	Age (years), n (%) ≤40	40-50	50-60	60-70	>70	P	Control group (n=8334) Total	Gender Female, n (%)	Gender Male, n (%)	P	Age (years), n (%) ≤40	40-50	50-60	60-70	>70	P
All	Pre	2539	1264 (49.8)	1275 (50.2)	0.817	986 (38.8)	354 (13.9)	543 (21.4)	340 (13.4)	316 (12.5)	0.238	4213	2122 (50.4)	2091 (49.6)	0.247	1759 (41.8)	625 (14.8)	820 (19.5)	504 (12.0)	505 (12.0)	0.180
	Post	2489	1231 (49.5)	1258 (50.5)		935 (37.6)	381 (15.3)	489 (19.7)	364 (14.6)	320 (12.9)		4121	2123 (51.5)	1998 (48.5)		1673 (40.6)	590 (14.3)	808 (19.6)	566 (13.7)	484 (11.7)	
CVC use	Pre	143	68 (47.6)	75 (52.5)	0.002	27 (18.9)	22 (15.4)	39 (27.3)	23 (16.1)	32 (22.4)	0.685	214	91 (42.5)	123 (57.5)	0.556	48 (22.4)	28 (13.1)	64 (29.9)	30 (14.0)	44 (20.6)	0.630
	Post	106	30 (28.3)	76 (71.7)		17 (16.0)	16 (15.1)	23 (21.7)	19 (17.9)	31 (29.3)		214	85 (39.7)	129 (60.3)		39 (18.2)	34 (15.9)	58 (27.1)	37 (17.3)	46 (21.5)	
No - CVC use	Pre	2396	1196 (49.9)	1200 (50.1)	0.739	959 (40.0)	332 (13.9)	504 (21.0)	317 (13.2)	284 (11.9)	0.273	3999	2031 (50.8)	1968 (49.2)	0.221	1711 (42.8)	597 (14.9)	756 (18.9)	474 (11.9)	461 (11.5)	0.215
	Post	2383	1201 (50.4)	1182 (49.6)		918 (38.5)	365 (15.3)	466 (19.6)	345 (14.5)	289 (12.1)		3907	2038 (52.2)	1869 (47.8)		1634 (41.8)	556 (14.2)	750 (19.2)	529 (13.5)	438 (11.2)	

CVC: Central venous catheter

costs for the index hospitalization [14]. A Systematic Review of Economic Evaluation of Quality Improvement Interventions for Bloodstream Infections Related to Central Catheters reported that interventions related to CVCs were, on average, associated with 57% fewer bloodstream infections and substantial savings to hospitals. Larger initial investments may be associated with greater savings [15].

Although the utilization of a CVC insertion care bundle impact after the pilot plan was implemented, it is our main goal to continue facilitating education, training, and basic and cost-effective tools and resources, to tackle this problem effectively and systematically.

Limitations

There is a possibility of some study bias due to unmeasured confounders such as comorbidities in studies of medications and health-care services. Therefore, when performing cross-unit comparisons, matters such as varying definitions and risk adjustments must be taken into account.

The US studies conducted over the past two decades have shown that at least 32% of medical treatment caused infections are preventable, which has an effect on the amount of medical insurance paid [16]. When the cost of a CVC is not covered by NHI, patients may have pay for it themselves when deemed necessary by their physicians. Data about the number of days that a CVC was used, related indication conditions, and the number of catheters used cannot be obtained directly from NHI data, marking one of the limitations of this study.

Indicator calculations varied in this study which hindered data comparisons, creating another limitation of this study. In one study, infection rate indicators varied considerably (i.e., as much as fourfold) when the definitions of bloodstream infections changed, highlighting possible errors and areas for improvement for administrative databases [17,18]. The annual data of the National Health Research Institute have yet to be released by the NHI Administration. Subsequent data analysis after the pilot plan was implemented may be done in the future.

Conclusions

Studies have shown that patients with medical treatment caused bloodstream infections pay NT$127,354–NT$155,904 more in medical expenses than patients without these infections. Thus, engaging in active CVC-associated sepsis monitoring can reduce medical expenses incurred and development of drug-resistant bacteria. In this study, data from the time that the NHI was introduced were utilized to analyze, for the first time, the implementation of CVC treatments and subsequent NHI coverage of medical expenses incurred to gain an insight into the benefits of the CVC care bundle promoted by medical centers [19]. The results indicated that the CVC care bundle lowered the CVC usage rate, length of hospitalization, medical expenses, the CVC associated sepsis rate, and antibiotics usage rate. These results showed that the implementation of the CVC care bundle by the government, NHI coverage, and use of infection control indicators may prevent infections.

Table 2: Comparison of length of hospital stay and medical expenses (mean±standard deviation)

	All			CVC use		
	Pre	Post	*P*	Pre	Post	*P*
Study group	7.49±7.51	7.22±7.57	0.1955	18.43±12.96	15.49±10.16	0.0462
Control group	7.27±8.30	7.06±6.86	0.2130	20.23±14.15	19.00±13.94	0.3642
P value for difference between groups			0.8495			0.4864
Study group	56,182.5±83,827.4	52,932.2±71510.7	0.1389	220,618±226419	208,079±193610	0.6466
Control group	52328.5±76040.1	54882.3±94475.0	0.1736	225973±205031	254006±292549	0.2516
P value for difference between groups			0.0635			0.3904

Table 3: Comparison of central venous catheter-associated sepsis between study and control groups

Detected date of bundle care plan	CVC used (*n*)	CVC-associated sepsis							*P*
		Study group			CVC used (*n*)	Control group			
		**n* (%)	OR	95% CI		*n* (%)	OR	95% CI	
Pre	143	18 (12.6)	1	0.16-1.09	214	38 (17.8)	1	0.37-1.10	0.4443
			0.42				0.64		
Post	106	6 (5.7)			214	26 (12.1)			

P value for difference OR between study and control group. The adjusted ORs were estimated from multiple logistic regression models with age and sex adjusted. CI: Confidence interval, OR: Odds ratio, CVC: Central venous catheter

Table 4: Comparison of antibiotics use during hospitalization, *n* (%)

Detected date of plan bundle care	Patient (*n*)	The use rate of antibiotics							*P*
		Study group			Patient (*n*)	Control group			
		n (%)	OR	95% CI		*n* (%)	OR	95% CI	
All inpatients									
Pre	3739	1788 (70.4)	1	0.87-1.10	4218	333 (7.9)	1	0.74-1.03	0.6970
Post	2489	1740 (69.9)	0.98		4121	287 (7.0)	0.87		
CVC use									
Pre	143	141 (98.6)	1	0.07-1.71	214	166 (77.6)	1	0.40-0.96	0.3768
Post	106	101 (95.3)	0.33		214	146 (68.2)	0.62		
No CVC									
Pre	2396	1647 (68.7)	1	0.89-1.13	3999	167 (4.2)	1	0.68-1.08	0.9650
Post	2383	1639 (68.8)	1.00		3907	141 (3.6)	0.86		

P value for difference OR between study and control group. The adjusted ORs were estimated from multiple logistic regression models with age and sex adjusted. CI: Confidence interval, OR: Odds ratio, CVC: Central venous catheter

Acknowledgments

We would like to acknowledge Wallace Academic Editing for translating this manuscript into English.

Financial support and sponsorship

This study was supported by Buddhist Tzu Chi General Hospital in 2015 (TCRD104-37). We express our most sincere gratitude to the Hualien Tzu Chi Hospital, Buddhist Tzu Chi Medical Foundation, whose donation made this study possible.

Conflicts of interest

There are no conflicts of interest.

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