

Cost-Benefit Analysis of Closed-System and Open-System Infusion of Human Serum Albumin in ICU Patients

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INTRODUCTION

- Human serum albumin (HSA) is primarily utilized in the intensive care unit (ICU) for fluid resuscitation and the management of hypoproteinemia in critically ill patients^[1,2]. In China there is a substantial clinical demand for HSA, with the average consumption per patient reaching as high as 152.5 grams^[3].
- HSA is predominantly available in two packaging formats: glass bottles and flexible bags, which correspond to open and closed infusion systems, respectively.
- Relevant research suggests that, compared to bottled HSA, bagged HSA administered via a closed infusion system not only reduces the incidence risk of central line-associated bloodstream infections (CLABSI)^[3] but also offers multiple advantages, including shortened preparation and administration time^[4] enhanced convenience in transportation and storage, lower medical waste disposal costs, and reduced wastage of residual drug solution.

OBJECTIVES

- Currently, economic evidence on the use of closed-system albumin among critically ill ICU patients remains limited. This study aims to evaluate the costs and benefits of closed-system (bagged) versus open-system (bottled) HSA infusion in ICUs in China from multiple analytical perspectives.

Method 1: Model Design

Model Features	
Model design	Decision tree model
Model perspectives	Healthcare provider, payer and patient
Target Patients	Patients in ICU
Model comparators	Closed-system HSA vs. Open-system HSA
Time horizon	1 year
Annual discount rate	No discount
Model Inputs	<ul style="list-style-type: none"> Drug cost Clinical efficacy Hospitalization related cost Medication preparation and management
Model outcomes of interest	<ul style="list-style-type: none"> Total costs Clinical outcomes

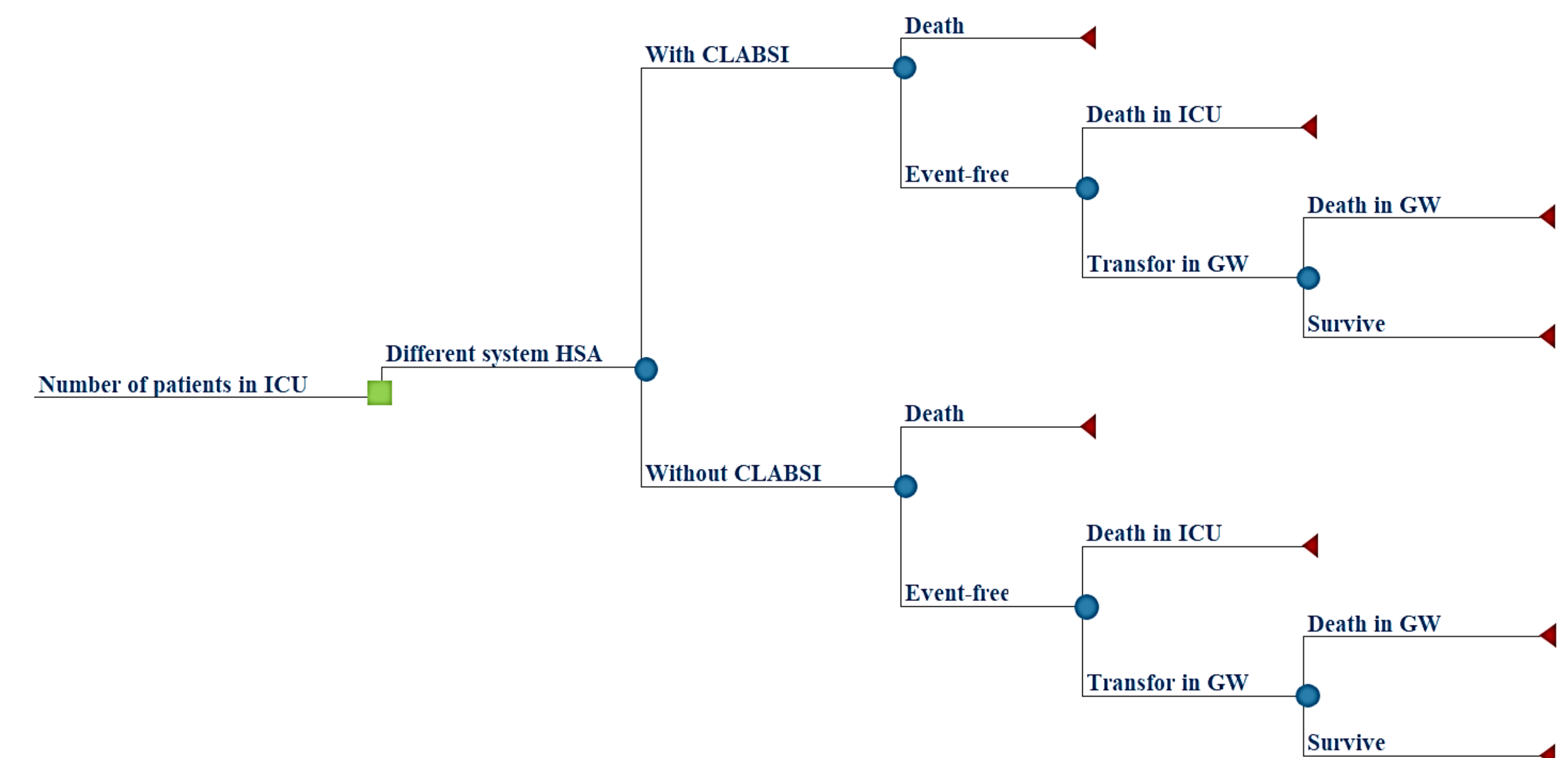


Figure 1: Diagram of Model Structure

Method 2: Model Inputs

- Model inputs were obtained from published literature and public data sources.
- All medical costs were inflated to 2025 Chinese yuan values based on China's historical inflation rate and then converted into 2025 US dollars using the December 2025 exchange rate (¥7.05 per \$1). Both types of HSA had the same specification: 10.0 g/50 mL.

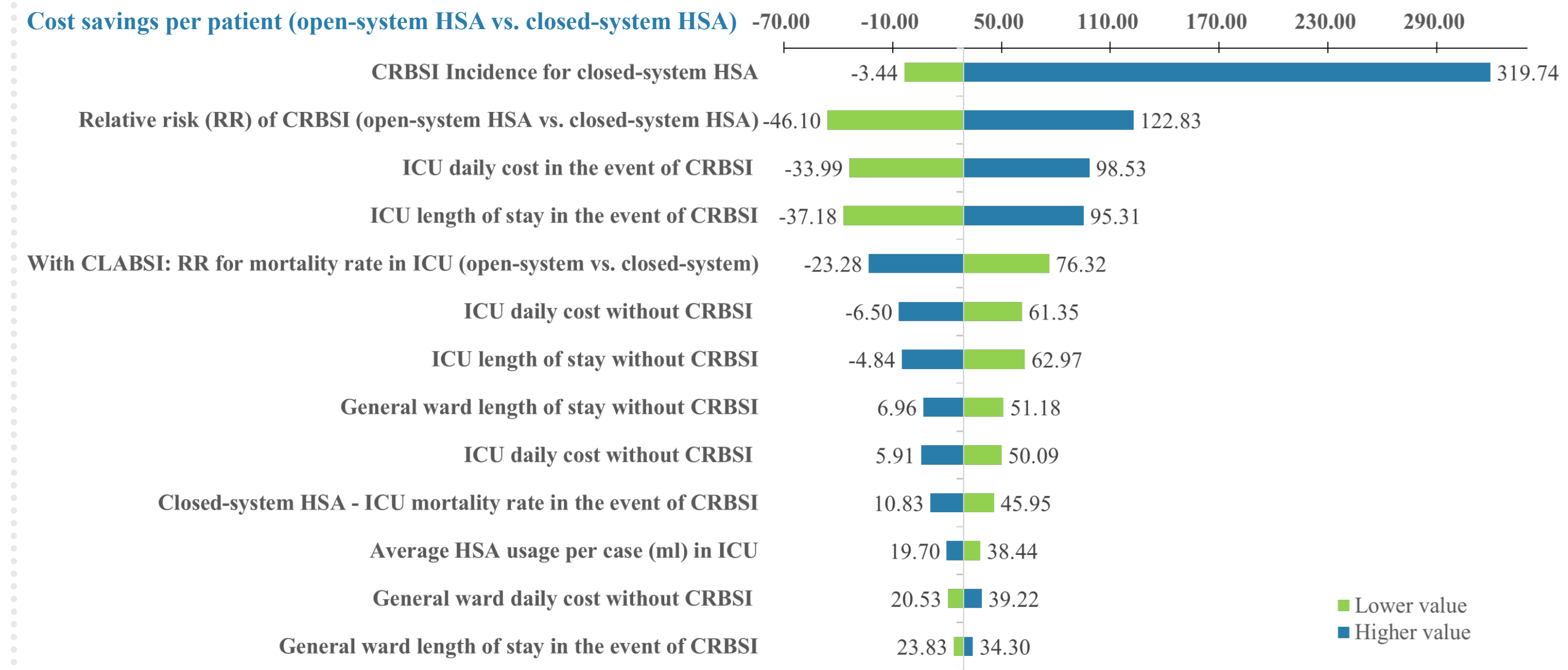
2.1 Key Model Inputs

Model Inputs	Closed-system HSA*			Open-system HSA*		
	Baseline	Lower value	Higher value	Baseline	Lower value	Higher value
1. Drug Cost Information						
Unit Price (\$/mL)	\$1.12	Fixed value		\$1.05	Fixed value	
Average HSA usage per case (mL) in ICU ^[3]	762.5	-	-	Same as the closed-system HSA		
2. Clinical Efficacy						
2.1 Length of Stay (LOS) ^[5-7]						
ICU length of stay in the event of CLABSI	31	24.924	37.076	Same as the closed-system HSA		
ICU length of stay without CLABSI	17	13.668	20.332	Same as the closed-system HSA		
General ward (GW) length of stay in the event of CLABSI	12	9.648	14.352	Same as the closed-system HSA		
GW length of stay without CLABSI	11	8.844	13.156	Same as the closed-system HSA		
2.2 CLABSI Incidence and Associated Mortality ^[4, 7-10]						
CLABSI incidence	0.60%	0.49%	1.60%	-	-	-
Relative risk (RR) of CLABSI (open-system HSA vs. closed-system HSA)	3.061	2.174	4.167	-	-	-
Initial mortality rate for CLABSI	3.17%	2.58%	3.82%	Same as the closed-system HSA		
Initial mortality rate for non-CLABSI	2.44%	1.47%	3.17%	Same as the closed-system HSA		
Closed-system HSA - ICU mortality rate in the event of CLABSI	16.90%	13.72%	20.34%	Same as the closed-system HSA		
ICU mortality rate without CLABSI	15.60%	12.67%	18.78%	Same as the closed-system HSA		
GW mortality rate in the event of CLABSI	11.60%	9.42%	13.97%	Same as the closed-system HSA		
With CLABSI: RR for mortality rate in ICU (open-system vs. closed-system)	1.302	1.149	1.471	-	-	-
2.3 ICU incidence of infectious complications ^[11-12]						
ICU incidence of infectious complications in the event of CLABSI	40.00%	32.30%	47.96%	Same as the closed-system HSA		
ICU incidence of infectious complications without CLABSI	19.01%	15.43%	22.87%	Same as the closed-system HSA		
ICU incidence of endocarditis in the event of CLABSI	17.00%	13.80%	20.46%	Same as the closed-system HSA		
ICU incidence of endocarditis without CLABSI	0.052%	0.042%	0.063%	Same as the closed-system HSA		
3. Hospitalization related cost (\$) ^[8,13]						
ICU daily cost in the event of CLABSI	\$910.38	\$740.72	\$1097.27	Same as the closed-system HSA		
ICU daily cost without CLABSI	\$843.29	\$686.14	\$1016.41	Same as the closed-system HSA		
GW daily cost in the event of CLABSI	\$246.34	\$167.58	\$339.80	Same as the closed-system HSA		
GW daily cost without CLABSI	\$174.19	\$141.73	\$209.95	Same as the closed-system HSA		
Antibiotic daily cost in the event of CLABSI	\$71.49	\$58.17	\$86.17	Same as the closed-system HSA		
Antibiotic daily cost without CLABSI	\$23.87	\$19.42	\$28.77	Same as the closed-system HSA		
Nursing cost per day	\$28.37	\$23.08	\$34.19	Same as the closed-system HSA		
4. Medication preparation and management ^[14-15]						
Preparation time (seconds/unit)	6.000	4.824	7.176	14.167	11.390	16.943
Medication waste (ml/unit)	0.065	0.052	0.078	0.108	0.087	0.130
Storage cost (\$/unit)	\$0.001	\$0.001	\$0.002	\$0.021	\$0.017	\$0.026
Waste container disposal cost (\$/unit)	\$0.213	\$0.173	\$0.256	\$0.511	\$0.415	\$0.615
Glass bottle breakage rate	0.000	-	-	0.100%	0.081%	0.121%

Result 1: Base-Case Analysis

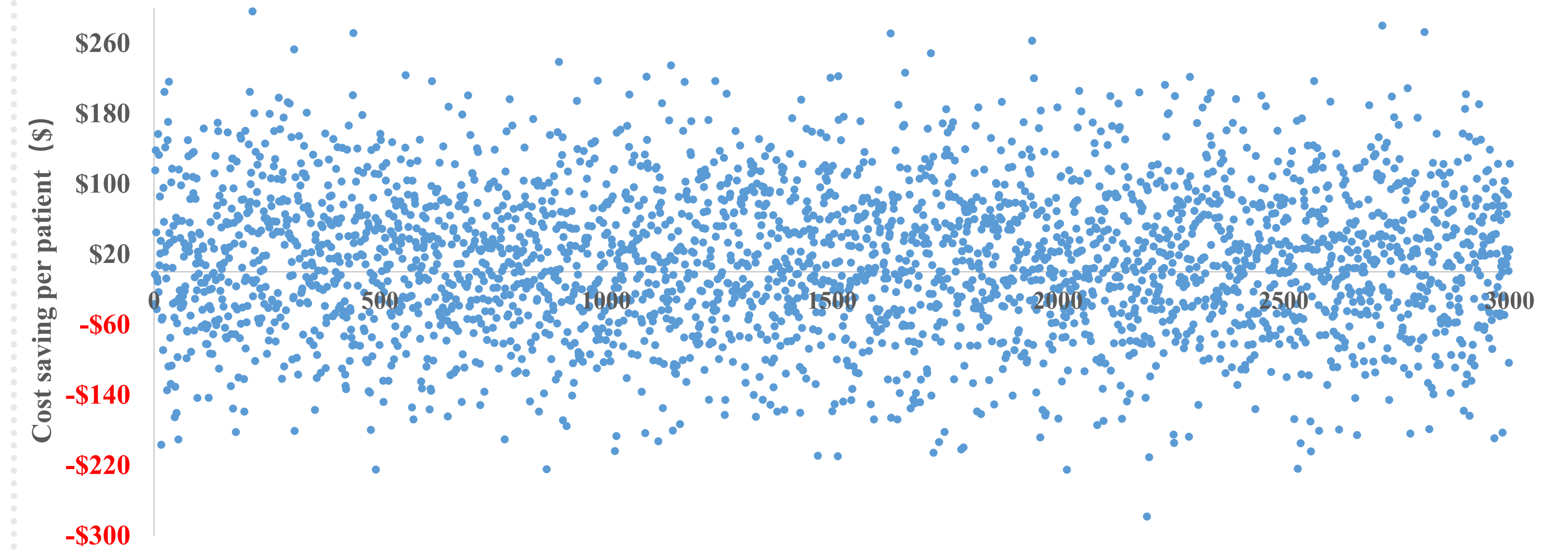
- In terms of cost, the closed-system HSA had a higher drug cost (\$89,623 vs. \$83,972), these were offset by lower hospitalization costs (\$1,564,513 vs. \$1,572,417), drug preparation costs (\$45 vs. \$107), and storage and management costs (\$343 vs. \$935). As a result, the closed-system HSA produced average per-case cost savings: \$29.07 (healthcare provider's perspective), \$13.51 (payer's perspective) and \$7.23 (patient perspective).
- Regarding consequences, closed-system HSA compared to open-system HSA resulted in lower mortality (28.36% vs. 32.80%), CLABSI incidence rate (0.60% vs. 1.84%), ICU bed occupancy rate (18.29% vs. 18.47%), ICU infection-related complications rate (19.14% vs. 19.40%), and ICU secondary endocarditis incidence rate (0.15% vs. 0.36%). Additionally, closed-system HSA reduced ICU length of stay (16.69 days vs. 16.86 days) without affecting GW length of stay. It also saved 218 minutes of drug preparation time and reduced medication waste (\$117 vs. \$182) for 100 simulated patients.

Result 2: One-Way Sensitivity Analysis (OWSA)



OWSA indicated that the 'CLABSI incidence for closed-system HSA' and 'Relative risk (RR) of CLABSI (open-system HSA vs. closed-system HSA)' were the most influential parameters.

Result 3: Probabilistic Sensitivity Analysis (PSA)



Based on 3,000 Monte Carlo simulations, PSA showed that closed-system HSA demonstrated a 67.5%, 62.5%, and 52.6% probability of being cost-saving relative to open-system HSA from the healthcare provider, payer, and patient perspectives, respectively.

- A unit cost difference analysis was conducted from the healthcare provider, payer, and patient perspectives. Compared with open-system HSA (10.0 g/50 mL), closed-system HSA (10.0 g/50 mL) demonstrated a unit cost advantage of \$5.35 (¥37.7), \$4.94 (¥34.8) and \$3.98 (¥28.1), respectively, indicating superior economic performance.
- Scenario analysis:** After replacing both types of HSA (10.0 g/50 mL) with HSA (12.5 g/50 mL) in the model, the results of the unit cost difference analysis remained unchanged. Compared with open-system HSA (10.0 g/50 mL), closed-system HSA (12.5 g/50 mL) showed a unit cost advantage of \$18.74 (¥132.09), \$18.18 (¥128.16) and \$17.00 (¥119.86) from the healthcare provider, payer, and patient perspectives, respectively.
- Closed-system HSA has obtained certification from the UK Carbon Trust for its lower carbon footprint, with carbon emissions reduced by 28% versus open-system HSA^[16]. It may also reduce aluminum particle leaching, thereby mitigating potential health risks^[17].

CONCLUSIONS

- In ICU settings, the use of closed-system HSA may be more cost-effective than open-system HSA, reducing medical costs, improving clinical outcomes, and bringing comprehensive benefits to healthcare institutions, patients, and the health insurance system.

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