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A benefit-cost analysis of the hospitalist care model in an acute medical unit

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ABSTRACT

Objective: This study aimed to assess the economic feasibility of the acute medical unit (AMU) hospitalist care model, utilizing patient outcomes from a previous investigation.

Design: A retrospective cohort study was conducted using benefit-cost analysis in terms of a societal perspective. Data relating to clinical factors, outcomes, and medical costs were obtained from the electronic medical record database at our institution. Literature-based costing was applied to determine direct non-medical costs and indirect costs that could not be obtained directly.

Setting: A tertiary care hospital in the Republic of Korea

Participants: We evaluated 6391 medical inpatients admitted through the emergency department (ED) from June 1, 2016, to May 31, 2017.

Interventions: The study compared multiple types of costs and benefits among inpatients from the ED between a non-hospitalist group and an AMU hospitalist group.

Results: This investigation found a significant 30% reduction in medical costs and a 24.3% reduction in total costs in the AMU hospitalist group compared to the non-hospitalist group ($e^{-0.355}$ = 0.701, P=0.000; $e^{-0.279}$=0.757, P=0.000). Furthermore, significant reductions in direct and indirect costs of 21.3% and 23.3% were found in the AMU hospitalist group compared to the non-hospitalist group ($e^{-0.240}$ = 0.787, P=0.000; $e^{-0.265}$=0.767, P= 0.000; respectively). The net-benefit and benefit-cost ratio (BCR) of the AMU hospitalist care group were US $8067 and 1.33 per capita, respectively.

Conclusions: The AMU hospitalist care model was associated with remarkable reductions in multiple costs. The net-benefit and BCR of the AMU hospitalist care showed consistent stability in the sensitivity analysis. Thus, AMU hospitalist care was found to be economically efficient.

Strengths and limitations of this study

·This is the first comprehensive benefit-cost analysis undertaken on a substantial cohort of inpatients to evaluate the economic feasibility of acute medical unit (AMU) hospitalist care in comparison to non-hospitalist care in terms of a societal perspective.

·The study encompassed all medical inpatients who were admitted from the emergency department to medical wards throughout the specified timeframe of June 1, 2016, to May 31, 2017. Having such broad inclusion criteria is likely to have enhanced the validity of the findings.

·It is challenging to make generalizations regarding this retrospective study due to its singular institution of origin.

·Expenditures apart from medical costs were not obtained directly but were calculated after consulting relevant sources; therefore, this is some degree of uncertainty in the cost estimates.

·As was the case in previous research on patient outcomes, this study could not quantify the potential benefits associated with a reduction in admissions to the intensive care unit. Therefore, it is possible that the benefits determined in this study were undervalued.

INTRODUCTION

In South Korea, a pilot hospitalist care system was implemented from 2016 to address reduced numbers of medical personnel and improve the quality of inpatient care [1]. The pilot project was integrated within the general hospital care system after 5 years and the number of hospitalists in Korea has increased to approximately 250 [2].

Since the implementation of the hospitalist care system in Korea, research on patient outcomes has been conducted [3−9] in terms of in-hospital mortality (IHM), intensive care unit (ICU) admission, emergency department-length of stay (ED-LOS) and total length of stay (LOS). Although there have been many studies on the effectiveness of the hospitalist system, few studies have been undertaken on costs or involving economic evaluations. While some studies have reported on the medical costs of hospitalist care in South Korea [7, 10], no economic evaluations from a societal perspective have been reported concerning hospitalist care in South Korea. Therefore, it is necessary to evaluate the economic feasibility of hospitalist care considering both its costs and effects in terms of whether it is efficient within the overall medical system.

In this study, a societal-perspective economic evaluation was conducted to estimate the overall costs and benefits of the acute medical unit (AMU) hospitalist care model implemented at our institution, based on patient outcomes. We aimed to provide new evidence on the economic efficiency of the AMU hospitalist care model.

METHODS

Study participants and AMU setting

We evaluated 6391 medical inpatients admitted through the emergency department (ED) of our institution from June 1, 2016, to May 31, 2017, who were assigned to AMU hospitalist care and non-hospitalist care groups (2426 and 3965 patients, respectively). The AMU patients were evaluated and treated by four hospitalists with an average of ten years of clinical experience in infectious diseases, pulmonology and critical care, nephrology, and endocrinology [9]. Seven days per week, two AMU hospitalists were responsible for the care of the AMU patients admitted during the day. In addition, non-hospitalist inpatient care was provided by subspecialists and residents in a specialty medical ward, where residents were primarily responsible for inpatient care under the supervision of an attending physician [9]. While hospitalist care in the AMU focused on general acute care, non-hospitalist care in the specialty medical ward emphasized long-term and specialized treatment [9].

Study design

This retrospective cohort study compared and analyzed the cost-saving benefits, calculated based on costs and patient outcomes, between AMU hospitalist care and non-hospitalist care groups for patients admitted through the ED at a tertiary hospital.

We conducted a benefit-cost analysis and divided costs into medical costs, non-medical costs, and time costs in terms of productivity loss [11]. This investigation was conducted in accordance with Consolidated Health Economic Evaluation Reporting Standards 2022 (CHEERS 2022) [12]. A flow diagram of the study population and benefit-cost factors is presented in Supplementary 1.

Ethics statement

The study protocol was approved by the Institutional Review Board of Seoul National University Bundang Hospital (approval number: B-1711/435-107) and the need for informed consent was waived.

Outcomes and clinical variables

Outcomes and clinical variables were obtained from the electronic medical records (EMRs) at our institution. Among the outcome variables, IHM, LOS and ED-LOS were used to calculate costs and benefits as well as the time cost of productivity loss.

We analyzed the following clinical variables of the participants: age, sex, prior hospitalization history, cardiopulmonary resuscitation (CPR) incidence, cause of ICU admission, referral to a specialty, consultations, surgical intervention (cases performed during the hospitalization, not before), major diagnosis (based on the International Statistical Classification of Diseases and Related Health Problems, 10th Revision, Australian Modification [ICD-10-AM]), and Korean Triage and Acuity Scale (KTAS), Age-adjusted Charlson Comorbidity Index (ACCI), and Acute Physiology and Chronic Health Evaluation (APACHE) II scores. The ACCI score is derived from the sum of 1, 2, 3, and 6 weighted values for 17 disease groups, ranging from 0 to 29; higher scores indicate higher severity [13]. The KTAS, which is currently applied in emergency medical centers in Korea, is a national standardized classification tool for evaluating illness severity [14]. We used the APACHE II score to compare the disease severity among ICU admissions; this score (range: 0-71) has been found to closely correlate with the risk of hospital death [15]. Baseline characteristics of the study population are presented in Table 1 [9].

Table 1. Baseline characteristics of patients cared for by hospitalists and non-hospitalists (N=6391)

Baseline Characteristics	Hospitalists (n=2426)	Non-hospitalists (n=3965)	*P value*
Sex			
Male	1387 (57.2)	2188 (55.2)	0.120
Female	1039 (42.8)	1777 (44.8)	
Age (years)	63.24±16.20	67.38±16.52	<0.001
<50	488 (20.1)	610 (15.4)	<0.001
50-59	401 (16.5)	499 (12.6)	
60-69	542 (22.3)	733 (18.5)	
70-79	632 (26.1)	1131 (28.5)	
≥80	363 (15.0)	992 (25.0)	
Prior hospitalization	2101 (86.6)	3373 (85.1)	0.090
Number of prior hospitalizations	3.16±4.07	3.24±4.20	0.480
Korean Triage and Acuity Scale			
1 (Resuscitation)	12 (0.5)	69 (1.7)	<0.001
2 (Emergency)	324 (13.4)	941 (23.7)	
3 (Urgent)	1699 (70.0)	2511 (63.3)	
4 (Less urgent)	367 (15.1)	403 (10.2)	
5 (Non-urgent)	24 (1.0)	41 (1.0)	
Major disease			
Malignant neoplasms	845 (34.8)	890 (22.4)	<0.001
Diseases of the circulatory system	48 (2.0)	552 (13.9)	
Diseases of the respiratory system	266 (11.0)	875 (22.1)	
Diseases of the digestive system	441 (18.2)	424 (10.7)	
Diseases of the genitourinary system	202 (8.3)	375 (9.5)	
Symptoms, signs, and abnormal clinical and laboratory findings	162 (6.7)	167 (4.2)	
Certain infectious and parasitic diseases	86 (3.5)	204 (5.1)	
Endocrine, nutritional, and metabolic diseases	95 (3.9)	158 (4.0)	
Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism	130 (5.4)	47 (1.2)	
Diseases of the musculoskeletal system and connective tissue	58 (2.4)	89 (2.2)	
Others	93 (3.8)	184 (4.6)	
Age-adjusted Charlson Comorbidity Index	3.82±2.63	3.77±2.19	
Median [IQR]	4 [2–5]	4 [2–5]	0.055
≤2	729 (30.0)	1018 (25.7)	0.001
3	436 (18.0)	733 (18.5)	
4	502 (20.7)	943 (23.8)	
≥5	759 (31.3)	1271 (32.1)	
Surgical intervention	282 (11.6)	560 (14.1)	0.004
CPR incidence	15 (0.6)	35 (0.9)	0.244
Consultation	1830 (75.4)	2946 (74.3)	0.312

Baseline Characteristics	Hospitalists (n=2426)	Non-hospitalists (n=3965)	*P value*
Number of consultations	3.50±6.18	3.99±7.02	0.004
Referral to a specialty	1613 (66.5)	450 (11.3)	<0.001
Type of specialty referral (n=2063)			
Hematology & Oncology	658 (40.8)	114 (25.3)	<0.001
Gastroenterology	360 (22.3)	20 (4.4)	
Respiratory	174 (10.8)	53 (11.8)	
Nephrology	96 (6.0)	11 (2.4)	
Infection	96 (6.0)	8 (1.8)	
Geriatrics	80 (5.0)	9 (2.0)	
Others	149 (9.2)	235 (52.2)	
Outcomes			
In-hospital mortality	117 (4.8)	361 (9.1)	<0.001
ICU admission	95 (3.9)	343 (8.7)	<0.001
Cause of ICU admission (n=438)			
Close monitoring after procedure or surgical intervention	55 (57.9)	223 (65.0)	0.077
Respiratory failure or insufficiency	23 (24.2)	78 (22.7)	
Septic shock	7 (7.4)	17 (5.0)	
Cardiovascular failure or insufficiency	7 (7.4)	12 (3.5)	
Metabolic/Renal failure	0 (0.0)	8 (2.3)	
GI bleeding	3 (3.2)	2 (0.6)	
Neurogenic dysfunction	0 (0.0)	3 (0.9)	
APACHE II score at ICU admission (n=438)	25.20±10.62	21.26±12.03	0.004
Length of hospital stay (days)	10.56±11.68	11.40±12.36	
Median [IQR]	7 [4–12]	8 [5–13]	0.007
ED-LOS (hours)	11.24±8.49	13.74±10.11	
Median [IQR]	8.4 [6.1–12.7]	10.2 [6.7–19.0]	<0.001
Re-admission within 10 days	117 (4.8)	177 (4.5)	0.507
Re-admission within 30 days	277 (11.4)	416 (10.5)	0.248

Data are presented as the mean ± standard deviation, number (%), or median [IQR], as indicated.
"surgical intervention" implies the patient underwent surgery during the hospital stay, not before.
IQR, interquartile range; CPR, cardiopulmonary resuscitation; ICU, intensive care unit; APACHE, Acute Physiology and Chronic Health Evaluation; ED-LOS, emergency department length of stay

Cost measures

Micro-costing and gross-costing were used for cost calculation in this study. Micro-costing was applied to directly calculate the medical costs during the total hospital stay [16]. Gross-costing was used to calculate all costs other than medical costs (Supplementary 2). The costs were classified into direct

costs and indirect costs [17], with all unit costs converted to United States (US) dollars as of 2017.

Direct costs

Direct costs comprised medical costs (micro-costing), family caregiver transportation fares, paid care costs, and doctor labor costs in hospitalization (gross-costing). Specifically, medical cost data were obtained from hospital administrative information in the EMRs at our institution regarding consultation fee, admission fee, medication fee (medication / injection / anesthesia / whole blood (WB) and blood product), treatment and surgery fee, medical examination fee (inspection / medical imaging / computed tomography [CT] / magnetic resonance imaging [MRI] / positron emission tomography [PET] / ultrasonography), therapeutic materials, and other factors (prosthetics, orthodontics / rehabilitation and physiotherapy / psychotherapy). The family caregiver transportation fare in relation to hospitalization was estimated by multiplying referenced costs (2017 Korea Health Panel Study [18] and the 2017 Consumer Price Index [19]) by patient individual LOS. The paid care cost was calculated by multiplying referenced average costs [20] by patient individual LOS. The doctor labor cost was calculated by dividing the doctors into hospitalists and residents and estimating the expenses in both groups based on daytime employment, as hospitalists were only present during this period. Resident doctor labor costs per patient were estimated using the following variables: the average after-tax salary (2017 resident training environment evaluation survey results [21]), four major social insurance scheme classifications (national pension, health insurance, employment insurance, and workers' compensation insurance [22]) and tax (income tax and resident tax [23]), the number of patients per physician [24], and the total LOS in the non-hospitalist care group. The AMU hospitalist labor costs per patient were calculated using a referenced average labor cost [25] and the AMU-LOS in the hospitalist care group.

Indirect costs

Indirect costs (time costs) were calculated by applying the gross-costing method. Patient productivity loss during hospitalization (time costs) was calculated by multiplying the average daily wage by gender

and age [26], by individual LOS, and by the labor force participation rate [27]. Family caregiver productivity loss was calculated by multiplying the average daily wage of all workers [26] by individual LOS. Patient productivity loss due to ED-LOS was calculated by multiplying the average hourly wage by gender and age [26], by individual ED-LOS, and by the labor force participation rate [27]. Patient productivity loss due to death in hospitalization was calculated by multiplying the average annual wage by gender and age [26], by the labor force participation rate [27], and by individual life years gained in relation to death [28]. Individual life years gained were estimated by subtracting life expectancy reduced by major diseases from life expectancy by gender and age, in reference to life tables available from the Korean Statistical Information Service (KOSIS, 2017) [28].

Benefit measure

In this study, the human capital approach was used as a method of evaluating the value of "health" or "life" in monetary units [16]. Benefits, in the form of cost savings, were then estimated based on direct and indirect costs.

Economic evaluation: benefit-cost analysis

In benefit-cost analysis, the benefit-cost ratio (BCR) and net-benefit are used as indicators for decision indices. Net benefit refers to benefit minus the cost, with a larger net benefit indicating a more favorable benefit-cost situation [16]. Therefore, we used BCR and net-benefit as indicators in terms of decision indices.

Sensitivity analysis

This study is a retrospective study of costs incurred. Since the study period comprised only one year, a discount rate was not applied to the costs and a sensitivity analysis was performed on uncertain variables [29]. The results of the sensitivity analysis are presented in a tornado diagram.

First, a sensitivity analysis was conducted on LOS and ED-LOS, which showed a skewed distribution. We analyzed the 1%-trimmed mean by calculating the average of the remaining values while excluding some (1%) from the extremes of the data. In addition, patients in the top 3% of LOS and ED-LOS were excluded as there were minimal numbers of patients from each group within this category.

Second, a sensitivity analysis was conducted on paid care costs among the direct non-medical costs that were considered to have high uncertainty. Assuming that no caregiver was hired, the baseline paid care costs were set at $64 [20], and the maximum daily paid care costs for hospitalized patients were set at $149) [20].

Third, a sensitivity analysis was conducted on doctor labor costs among the direct non-medical costs that were considered to have high uncertainty, with both one-way and two-way sensitivity analyzes conducted. Resident labor costs were set at $53,977 as a baseline, with a minimum value of $45,633 and a maximum value of $64,349 [21]. Hospitalist labor costs were set at $141,056 as a baseline [25], with a minimum value of $93,414 and a maximum value of $186,829.

Statistical analysis

Categorical variables are reported as percentages, and continuous variables as mean ± standard deviation (SD). Groups were compared using Pearson's chi-square tests or t-tests, as appropriate. ACCI, LOS, and ED-LOS were expressed as the median and interquartile range (IQR). For these variables, groups were compared using the Mann-Whitney *U* test, owing to their skewed distributions. We performed subgroup analyses of costs and benefits according to age, severity of the patient's condition (based on the KTAS score), the degree of comorbidity (based on the ACCI score), and the major disease category (based on the ICD-10). Natural log-transformed multivariate regression analysis was conducted in relation to the costs. Since the unit cost was large, using a natural logarithm can increase normality and enable accurate values to be obtained during analysis as well as reduce skewness and kurtosis of the data. Regression analysis for the costs was used to adjust for the following factors: age, sex, prior hospitalization, referral to specialty, consultation, CPR, KTAS score, ACCI score, surgical

intervention, major disease, ICU admission, IHM, LOS, and ED-LOS. Using the estimates from the regression models, we presented differences between AMU hospitalized and non-hospitalized groups in terms of medical, direct, indirect, and total costs.

Patient and public involvement

This was a non-interventional study conducted retrospectively. Consequently, no patients participated directly in the study's conception, formulation of research objectives and queries, or execution. In addition, patients were not involved in the interpretation of results or production of the manuscript. It is not currently in our intentions to disseminate the findings to the study participants.

RESULTS

Costs

All costs are presented as costs per capita in this study. The estimated 2017 costs (US $1= 1070.5 KRW, year: 2017 [30]) between the hospitalist group and the non-hospitalist group are shown in Table 2. The total costs were significantly lower in the hospitalist group than in the non-hospitalist group, with a difference of more than $8000 (24509±110990 *vs.* 32576±124893, *P*=0.009). The direct medical costs were significantly lower in the hospitalist group than in the non-hospitalist group, with a difference of more than $1,000 (4978±7946 *vs*. 6170±8864, *P*= 0.000).

Among the subcategories of medical costs, the biggest difference was found in relation to the admission fee and medical examination fee (1083±2029 *vs.* 1425±2073, *P*=0.000; 1551±1991 *vs.* 1912±2048, *P*=0.000; respectively). Among the direct non-medical costs, the family caregiver transportation fare and paid care costs were significantly lower in the hospitalist group than in the non-hospitalist group (*P*=0.007 and *P*=0.007, respectively).

However, doctor labor costs were approximately three times higher in the hospitalist group than in the non-hospitalist group (299±168 *vs.* 99±108, *P*=0.000). The indirect costs were significantly lower in the hospitalist group than in the non-hospitalist group, with a difference of more than $6000 (18312±109195 *vs.* 25313±123018, *P*=0.021). Among the indirect costs, family caregiver productivity loss according to LOS and patient productivity loss according to ED-LOS and IHM were significantly lower in the hospitalist group than in the non-hospitalist group (*P*=0.007, *P*=0.000 and *P*=0.023, respectively). However, there were no significant differences between the two groups in terms of patient productivity loss according to LOS (684±955 *vs.* 670±963, *P*=0.570).

Table 2. Costs of patients cared for by hospitalists and non-hospitalists (N=6391)

Cost per capita (USD)	HG (n=2426)	NHG (n=3965)	*P* value
Total costs	24509±110990	32576±124893	0.009
Direct costs	6198±8915	7263±9823	0.000
Direct medical costs	4978±7946	6170±8864	0.000
Consultation fee	307±270	329±290	0.003
Admission fee	1083±2029	1425±2073	0.000
Medication fee	1108±2865	1086±2839	0.774
Treatment and surgery fee	325±1334	528±2102	0.000
Medical examination fee	1551±1991	1912±2048	0.000
Therapeutic materials	372±1058	675±1804	0.000
Others	234±728	215±571	0.249
Direct non-medical costs	1219±1119	1093±1185	0.000
Family caregiver transportation fare in hospitalization	242±267	261±283	0.007
Paid care cost in hospitalization	679±750	733±794	0.007
Doctor's labor cost	299±168	99±108	0.000
Indirect costs	18312±109195	25313±123018	0.021
Patient productivity loss according to LOS	684±955	670±963	0.570
Family caregiver productivity loss according to LOS	1374±1519	1483±1608	0.007
Patient productivity loss according to ED-LOS	93±91	105±110	0.000
Patient productivity loss according to IHM	16161±108728	23056±122666	0.023

Data are presented as mean ± standard deviation. HG, hospitalist group; NHG, non-hospitalist group; ED-LOS, emergency department length of stay; LOS, length of hospital stay; IHM, in hospital mortality; Cost unit: USD (U.S. Dollar), ($1= 1070.5 KRW, year: 2017)

Subgroup cost differences according to KTAS scores, comorbidity severity, major disease, and age

Cost analysis was performed according to subgroups of patients stratified by KTAS scores, ACCI scores, major disease, and age to determine differences between the two groups (Supplementary 3, 4, 5 and 6). Compared to the non-hospitalist group, the hospitalist group's overall costs for more urgent cases were significantly reduced by more than $9000 (*P*=0.002). In low-to-moderate comorbidity groups (ACCI = 0-2, 3 and 4 points), there was a greater cost reduction in the hospitalist group than in the non-hospitalist group ($15485, *P*=0.036; $11886, *P*=0.163; $9688, *P*=0.019; respectively).

Among the major diseases, in all but three disease types, the overall costs in relation to the hospitalist group decreased compared to the non-hospitalist group. In a subgroup analysis by age, total costs in the hospitalist group decreased in almost all age groups (*P*=0.256, *P*=0.004, *P*=0.001, *P*=0.003; respectively).

Natural log-transformed multivariate regression analysis of costs

We performed natural log-transformed multivariate regression analysis to adjust for clinical variables and outcome variables potentially associated with costs, namely, medical, direct, indirect, and total costs (Supplementary 7 and 8). Regression analysis revealed a significant 30% reduction in medical costs and a 24.3% reduction in total costs in the hospitalist group compared to the non-hospitalist group ($e^{-0.355} = 0.701$, *P*=0.000; $e^{-0.279}=0.757$, *P*=0.000). Furthermore, there was a significant reduction of 21.3% in direct costs and a 23.3% reduction in indirect costs in the hospitalist group compared to the non-hospitalist group ($e^{-0.240} = 0.787$, *P*=0.000; $e^{-0.265}=0.767$, *P*= 0.000; respectively).

Benefit-cost analysis

Net-benefit and BCR analysis were conducted according to total and subgroups of patients stratified by clinical variables, KTAS scores, ACCI scores, major diagnoses, and age (Table 3). Among the total group of patients, the net-benefit and BCR of the AMU hospitalist care group were $8067 and 1.33 per

capita, respectively; AMU hospitalist care was evaluated as economically feasible. Among the patients stratified by clinical variables, net-benefit and BCR analysis results indicated that AMU hospitalist care was economically feasible in all but five 5 subgroups (urgent; ACCI ≥5; diseases of the circulatory system; diseases of the genitourinary system; and endocrine, nutritional and metabolic diseases).

Table 3. Benefit-cost analysis

Total Cost per capita (USD)	HG (A)	NHG (B)	Net-benefit (B-A)	B/A ratio (benefit cost ratio, BCR)
Total (N=6391)	24509	32576	8067	1.33
KTAS				
More urgency (n=5556)	24214	34596	10381	1.43
Less urgency (n=835)	26045	16562	-9483	0.64
ACCI				
ACCI ≤2 (n=1747)	20003	35488	15485	1.77
ACCI=3 (n=1169)	29935	41822	11886	1.40
ACCI=4 (n=1445)	16921	26609	9688	1.57
ACCI≥5 (n=2030)	30740	29339	-1400	0.95
Major disease				
Malignant neoplasms (n=1735)	44490	76101	31612	1.71
Diseases of the circulatory system (n=600)	25810	12727	-13083	0.49
Diseases of the respiratory system (n=1141)	14341	21647	7306	1.51
Diseases of the digestive system (n=865)	12333	23432	11099	1.90
Diseases of the genitourinary system (n=577)	16620	13842	-2778	0.83
Symptoms, signs and abnormal clinical and laboratory findings (n=329)	7800	12610	4811	1.62
Certain infectious and parasitic diseases (n=290)	6126	26372	20246	4.31
Endocrine, nutritional and metabolic diseases (n=253)	16495	6323	-10171	0.38
Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism (n=177)	14823	78742	63919	5.31
Diseases of the musculoskeletal system and connective tissue (n=147)	10444	22650	12207	2.17
Others (n=277)	22861	33371	10510	1.46
Age (years)				
<50 (n=1098)	41296	55982	14686	1.36
50-59 (n=900)	43701	80904	37203	1.85
60-69 (n=1275)	16962	26750	9789	1.58
70-79 (n=1763)	13784	18436	4652	1.34
≥80 (n=1355)	10683	14300	3617	1.34

Data are presented as mean. HG, hospitalist group; NHG, non-hospitalist group; KTAS, Korean Triage and Acuity Scale; ACCI, Age-adjusted Charlson Comorbidity Index; Cost unit: USD (U.S. Dollar), ($1= 1070.5 KRW, year: 2017)

Sensitivity analysis

The sensitivity analysis results for LOS and ED-LOS are shown in Figures 1-1 and 1-2. We analyzed the 1%-trimmed mean and excluded patients with extreme values, as noted. After excluding extreme values related to LOS, the results were stable (net-benefit; \$7162 to \$8555, BCR; 1.30 to 1.38) and showed no significant difference from the initial analysis. Sensitivity analysis for ED-LOS revealed that the results were consistent (net-benefit; \$7412 to \$7860, BCR; 1.30 to 1.33) and showed no significant difference from the initial analysis. After varying paid care costs from \$0 to \$149, the sensitivity analysis results were stable, with the net benefit ranging from \$8013 to \$8138 and the BCR from 1.32 to 1.34 (Figure 1-3). One-way sensitivity analysis results showed comparative values of resident labor costs and hospitalist labor costs (Supplementary materials 9 and 10), with resident labor costs ranging from \$45,633 to \$64,349, which indicated a net benefit ranging from \$8062 to \$8073 (BCR, 1.33) (Supplementary 9). After varying hospitalist labor costs from \$93,414 to \$186,829, the results were stable, with net benefit ranging from \$7991 to \$8145 (BCR, 1.33) (Supplementary 10). Two-way sensitivity analysis results on doctor labor costs are presented in Figure 2 and Supplementary 11. These indicated consistent and stable outcomes, with the net benefit ranging from \$7986 to \$8152 (BCR, 1.33).

DISCUSSION

Study summary

This study is the first to report on the economic efficiency of a Korean AMU hospitalist care model while controlling for clinical factors. We found a notable cost reduction with AMU hospitalist care compared to non-hospitalist care in all areas; medical costs, direct costs, indirect costs, and total costs. In this study, medical costs included hospitalist care fees. The same trend toward cost reduction was observed in the subgroup and regression analyses.

The net-benefit and BCR analysis results of the AMU hospitalist care group were \$8067 and 1.33 per capita, respectively; AMU hospitalist care was evaluated as economically efficient. Sensitivity analysis

showed that the net-benefit and BCR results in terms of AMU hospitalist care were stable. Direct, real-time communication among our multidisciplinary team members, which enables appropriate and quick decision-making on treatments for patients with acute diseases, is a key component of our AMU care [3]. As a result, direct medical expenses have decreased. Furthermore, our previous study reported that AMU hospitalist care considerably improved patient outcomes in terms of IHM, ICU admission rate, LOS and ED-LOS [9]. This enhanced performance has led to a reduction in indirect expenses and in productivity loss.

Direct medical costs

Some previous studies that investigated the costs of hospitalist care have reported reduced medical costs in hospitalist care [10, 31-38]. In contrast, other studies have reported no significant difference in total medical costs between patients treated by hospitalists and those treated by non-hospitalists [7, 39] and that the costs of care for hospitalists were more than those for specialists but less than those for generalists [40]. Our study showed that there was a marked cost reduction in consultation, admission, treatment and surgery, medical examination, and therapeutic materials fees among the medical cost subcategories. Even when hospitalist care fees were included in medical costs, the hospitalist group's medical costs were lower, which indicates that the difference would be even greater if hospitalist care fees were excluded. Among the previous studies, one study that evaluated Korean hospitalists reported that medical costs reduced by $255 in terms of hospitalist care [10]. However, in our study, medical expenses per admission decreased by more than $1000 in the hospitalist care group. The findings of research on medical cost reduction are consistent, but our study's findings on cost-reduction suggest a more substantial reduction is involved.

The patient group in our study consisted of patients with acute medical conditions admitted through the ED of a tertiary general hospital, with their disease severity being higher than that among those in the total group of patients, which may explain the difference in study results. However, the regression analyses showed a significant 30% reduction in medical costs in the hospitalist group after adjusting for

clinical factors. Despite the conflicting results reported in earlier studies, our research findings offer compelling evidence supporting the effectiveness of the AMU hospitalist care model in reducing medical costs.

Direct non-medical costs compared with indirect costs

Studies are lacking on the economic implications of hospitalist care from a societal perspective. Hence, we conducted an estimation and analysis of non-medical expenses to assess the economic feasibility of AMU hospitalist care from a societal perspective.

In a previous study, we reported that AMU hospitalist care considerably improved patient outcomes in terms of IHM, ICU admission rate, LOS, and ED-LOS [9]. In this study, we used patient outcomes from that study to estimate the following costs: family caregiver transportation fares in hospitalization, paid care costs in hospitalization, patient productivity loss based on LOS, family caregiver productivity loss based on LOS, patient productivity loss based on ED-LOS, and patient productivity loss based on IHM.

The hospitalist care group's decreased LOS resulted in a notable reduction in expenses related to family caregiver transportation and paid care during patient hospitalization. However, the doctor labor cost in the hospitalist group was almost three times higher than that in the non-hospitalist group. Therefore, direct non-medical costs were higher in the hospitalist group.

With the exception of patient productivity loss based on LOS, substantial reductions in expenses were shown for family caregiver productivity loss based on LOS and patient productivity loss based on ED-LOS and IHM. The hospitalist group exhibited a considerably reduced LOS in comparison to the non-hospitalist group [9]. However, it is possible that the lower age of the patients in the hospitalist group may account for the larger patient productivity loss based on LOS observed in this group. Nevertheless, AMU hospitalist care resulted in notable reductions in the indirect costs, surpassing $7000 in savings when compared to the non-hospitalist group. This improvement in patient outcomes played a pivotal role in achieving these cost reductions. Therefore, the overall costs in relation to the

AMU hospitalist care group showed a notable decrease in comparison to the non-hospitalist group.

Benefit-cost analysis

The net-benefit and BCR analysis of the AMU hospitalist care group gave results of $8067 and 1.33 per capita, respectively, indicating that AMU hospitalist care was economically feasible. However, variations in net-benefit and BCR analysis ranges were seen across different subgroups (-$13083 to $63919, 0.38 to 5.31; respectively). This indicates that the economic efficacy of AMU hospitalist care varies based on the clinical characteristics of patients. Nevertheless, in terms of net-benefit and BCR results, AMU hospitalist care was found to be economically feasible in 17 subgroups and not feasible in five subgroups. These findings might potentially serve as a valuable reference for the development of a more efficient hospitalist care paradigm in further research.

A one-way sensitivity analysis was conducted to examine the impact of variations in the LOS, ED-LOS, paid care costs, and doctor labor costs. The net-benefit and BCR analysis results of AMU hospitalist care were stable based on a one-way sensitivity analysis using these four variables. The results of a two-way sensitivity analysis indicated that the net-benefit and BCR results of AMU hospitalist care remained consistent despite fluctuations in labor costs for both residents and hospitalists.

Limitations

This study had some restrictions. First, it employed a retrospective design, which posed challenges in mitigating the effect of confounding factors and discerning whether the observed results were attributable to the AMU environment or the treatment administered by the hospitalists. Second, the study was conducted at a single site, which limits the extent to which our findings may be generalized. Third, other expenditures, excluding medical expenses, were not directly obtained but rather calculated by consulting relevant sources, which introduced a degree of uncertainty into the cost estimations. Fourth, the present study could not provide a quantifiable assessment of the potential benefits associated with the reduction of ICU admissions, which has also been a limitation in related prior research on patient outcomes. Hence, it is possible that the advantages identified in this study may have been

undervalued.

CONCLUSION

This study showed that AMU hospitalist care significantly reduced costs in nearly all categories, including medical costs, direct costs, indirect costs, and total costs. Moreover, in the benefit-cost analysis, the net-benefit and BCR results of the AMU hospitalist care group were consistently shown to be greater than $8000 and 1.30 per capita, respectively. These results indicate that AMU hospitalist care is economically efficient.

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Author Contributions

Conceptualization: Kim HJ, Kim JH, Ohn JH, Kim N-H. Methodology: Kim HJ, Kim JH, Ohn JH, Kim N-H. Software: Kim HJ. Validation: Kim HJ, Kim JH, Ohn JH, Kim N-H. Formal analysis: Kim HJ. Investigation: Kim HJ, Kim JH, Ohn JH, Kim N-H. Data curation: Kim HJ. Writing – original draft: Kim HJ. Writing - review & editing: Kim HJ, Kim JH, Ohn JH, Kim N-H. All authors have read and approved the final draft of the manuscript. JK is guarantor.

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Competing interests

The authors have no potential conflicts of interest to disclose.

Patient consent for publication

Not applicable.

Ethics approval

Ethical approval was provided by the Institutional Review Board of Seoul National University Bundang Hospital (IRB No. B-1711/435-107). Our institution's ethics committee waived the need for informed consent owing to the retrospective nature of the study and the use of anonymized data previously collected for routine clinical care.

Data availability statement

Data are available from the corresponding author upon reasonable request.

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Figures

Figure 1. One-way sensitivity analysis for the length of hospital stay, emergency department-length of stay and paid care cost

Figure 2. Two-way sensitivity analysis for doctor labor cost

Supplementary Materials

Supplementary 1. A flow diagram of the study population and benefit-cost factors

Supplementary 2. Type of costs, cost estimation formula, and data source

Supplementary 3. Cost analysis for urgent and non-urgent cases treated by hospitalists or non-hospitalists (N=6391)

Supplementary 4. Cost analysis for patients with different comorbidity severities treated by hospitalists or non-hospitalists (N=6391)

Supplementary 5. Cost analysis according to major diseases between hospitalist and non-hospitalist groups (N=6391)

Supplementary 6. Cost analysis according to age between hospitalist and non-hospitalist groups (N=6391)

Supplementary 7. Natural log-transformed multivariate regression analysis for medical costs and

total costs (N=6391)

Supplementary 8. Natural log-transformed multivariate regression analysis for direct costs and indirect costs (N=6391)

Supplementary 9. One-way sensitivity analysis for resident labor costs

Supplementary 10. One-way sensitivity analysis for hospitalist labor costs

Supplementary 11. Two-way sensitivity analysis for doctor labor costs

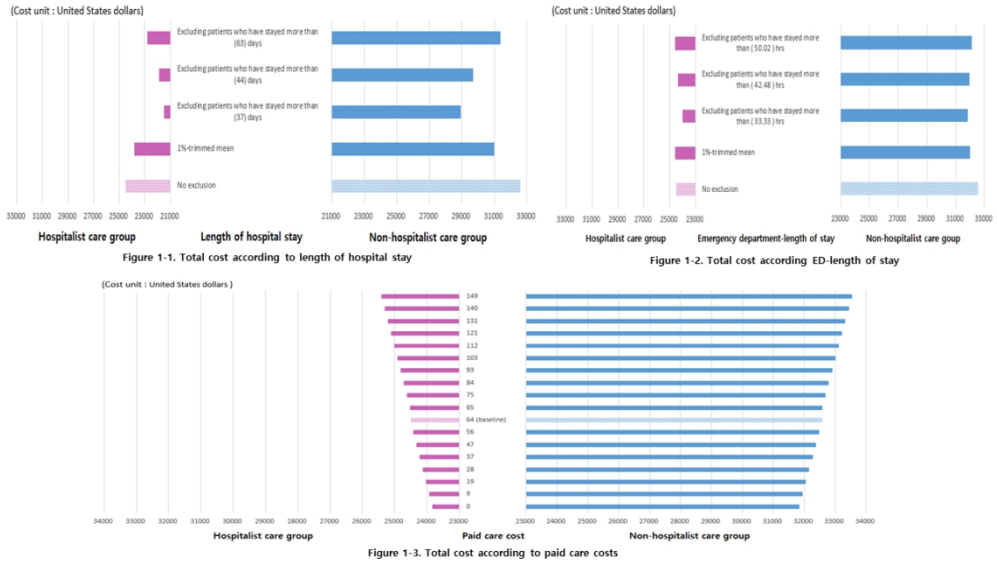


Figure 1. One-way sensitivity analysis for the length of hospital stay, emergency department-length of stay and paid care cost

855x481mm (38 x 38 DPI)

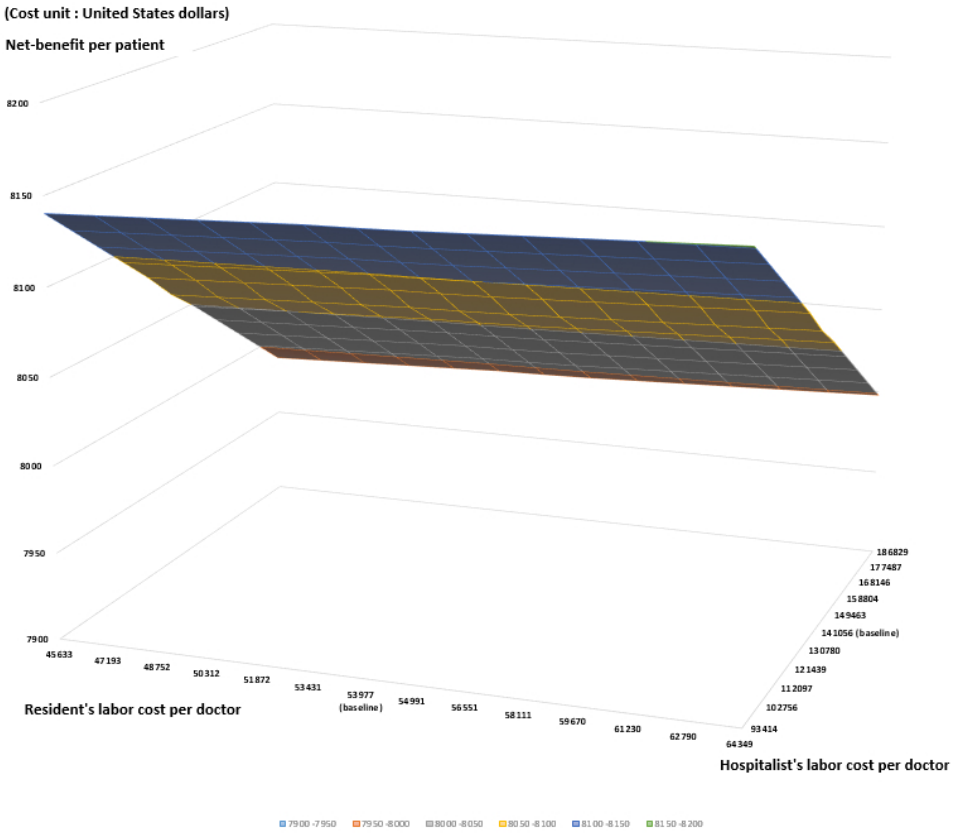
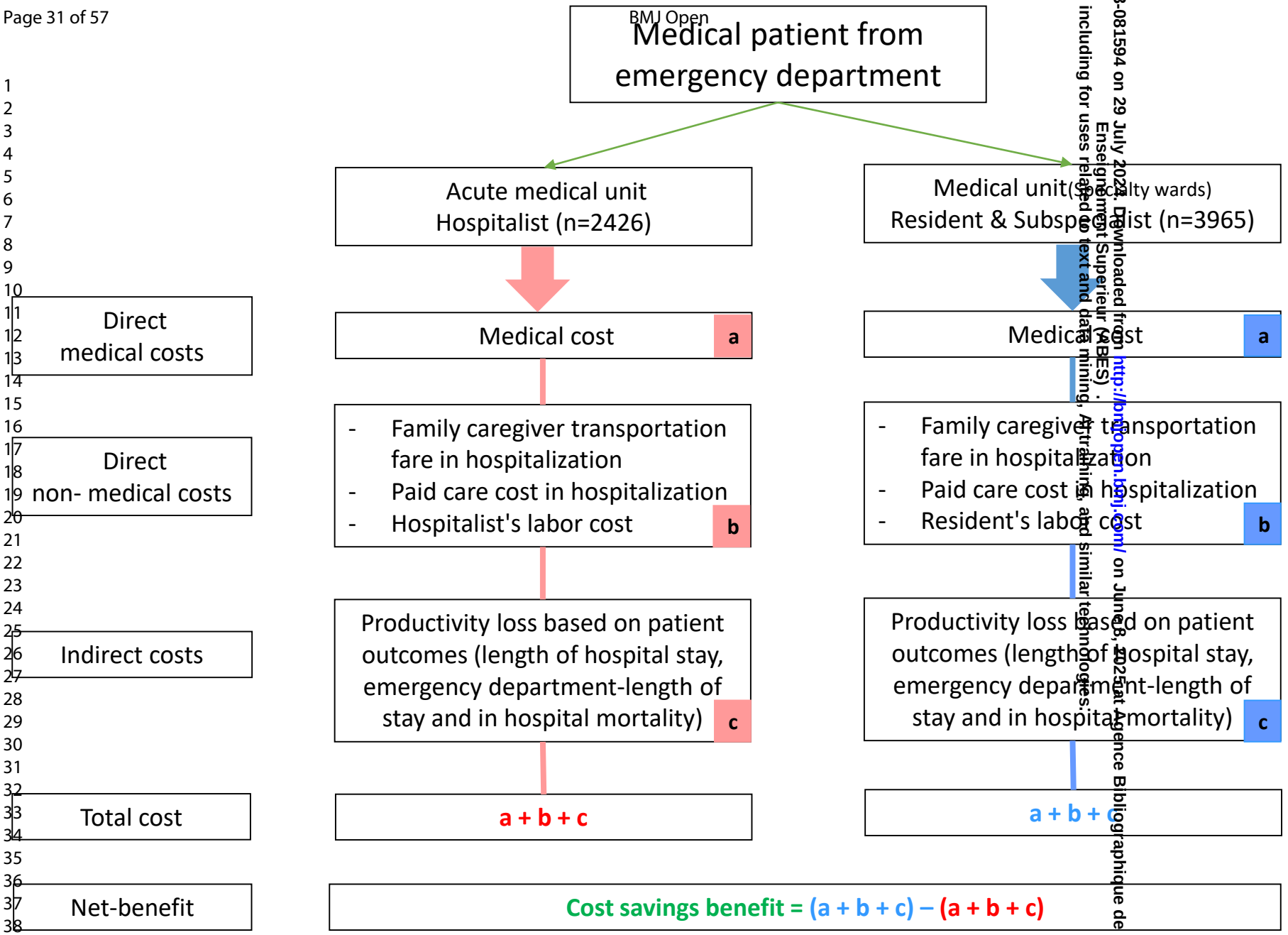


Figure 2. Two-way sensitivity analysis for doctor labor cost

530x456mm (38 x 38 DPI)



Supplementary 1. A flow diagram of the study population and benefit-cost factors

Supplementary 2. Type of costs, cost estimation formula and data source

Type of costs	Cost estimation formula & data source
Direct costs	C1 + C2 + C3 + C4
Direct medical costs	C1
Total medical expense in hospitalization (C1)	Individual medical treatment bill receipt (real data) ① consultation fee ② admission fee ③ medication fee (including medication / injection / anesthesia / WB and blood product) ④ treatment and surgery fee ⑤ medical examintaion fee (including inspection / medical imaging / CT / MRI /PET / Ultrasonography) ⑥ therapeutic materials ⑦ the others (prosthetics, orthodontics / rehab and physiotherapy / psycotherapy)
Direct non-medical costs	C2 + C3 + C4
Family caregiver transportation fare in hospitalization (C2)	$23 * LOS 2017 Korea health panel study / 2019 Annual report on the consumer price index (referenced data), LOS : real data
Paid care cost in hospitalization (C3)	$64 * LOS The Social Cost of Informal Nursing Care and its Policy Implications for Integrated Nursing and Care Services (2021)(referenced data), LOS : real data
Doctor's labor cost (C4)	
Resident's labor costs (day shift)	2017 resident training environment evaluation survey results
Salary after tax	$32695 ~ $43905, average salary after tax : 37693 $
Resident's labor costs per doctor	$45633 ~ $64349 Estimating using 4 Major SIS's (Social Insurance Schemes; national pension, health insurance, employment insurance, workers' compensation insurance) and tax (income tax and resident tax)
Resident's average labor costs per doctor	$53977
Number of inpatient per day per doctor	17
Number of inpatients per year per doctor	17*365=6,205
Total number of resident assigned to the NHG group	Total LOS of the control group (45,196) / 6,205 =7.3
Total Resident's labor costs in the in the NHG group	$53977 * 7.3 = $394035
Resident's labor costs per patient per day in the NHG group	$394035 / 45,196 = $9
Resident's labor costs per patient in the NHG group	$9 * LOS per admission
Hospitalist's labor costs (day shift)	A study on the implementation and the evaluation of Korean hospitalist system to improve the quality of hospitalization (phase 2)(2018)
Hospitalist's labor costs per doctor	average 141056 $ (including salary and operation cost)
Total number of hospitalist assigned to the HG group	4
Hospitalist's labor costs per patient per day of AMU in the HG group	$564222 / 7216 (Total AMU-LOS) = $78

Type of costs	Cost estimation formula & data source
Doctor's labor cost per patient in the HG group	
1) No referral patients	$78 * AMU-LOS
2) Referral patients	($78 * AMU-LOS) + ($9 * referral medical ward-LOS)
Indirect Costs	C5 + C6 + C7 + C8
Family caregiver productivity loss according to LOS (C5)	$130 * LOS 2017 Survey report on labor conditions by employment type (referenced data), LOS (real data)
Patient productivity loss according to ED-LOS (C6)	Hourly wage * ED-LOS * labor force participation rate (age, gender) 2017 Survey report on labor conditions by employment type (referenced data) 2017 Annual report on the the economically active population survey (referenced data), ED-LOS (real data)
Patient productivity loss according to LOS (C7)	Daily wage * LOS * labor force participation rate (age, gender) 2017 Survey report on labor conditions by employment type (referenced data) 2017 Annual report on the the economically active population survey (referenced data)
Patient productivity loss according to IHM (C8)	Annual wage * deceased patients' expected LYGs * labor force participation rate (age, gender) Statistics Korea. LIFE TABLES FOR KOREA, 2017 (referenced data) 2017 Survey report on labor conditions by employment type (referenced data) 2017 Annual report on the the economically active population survey (referenced data) In hospital mortality (real data)

HG, hospitalist group; NHG, non-hospitalist group; AMU, acute medical unit; LOS, length of hospital stay; ED, emergency department; Cost unit: USD ($1= 1070.5 KRW, year: 2017)

Supplementary 3. Cost analysis for urgent and non-urgent cases treated by hospitalists or non-hospitalists (N=639)

	KTAS 1-3: More Urgent (N=5556)			KTAS 4-5: Less Urgent (N=835)		
Cost per capita (USD)	**HG (n=2035)**	**NHG (n=3521)**	***P* value**	**HG (n=391)**	**NHG (n=444)**	***P* value**
Total costs	24214±110059	34596±130253	0.002	26045±115849	16562±66914	0.155
Direct costs	6280±8991	7375±10045	0.000	5770±8507	6375±7795	0.284
Direct medical costs	5055±7979	6275±9075	0.000	4578±7774	5340±6923	0.135
Consultation fee	312±278	332±291	0.009	284±224	301±279	0.319
Admission fee	1100±2143	1446±2109	0.000	993±1278	1260±1751	0.013
Medication fee	1121±2477	1101±2835	0.791	1039±4362	973±2870	0.794
Treatment and surgery fee	334±1368	554±2196	0.000	277±1139	321±1080	0.564
Medical examination fee	1574±2057	1574±2057	0.000	1432±1599	1712±1747	0.016
Therapeutic materials	1574±2057	1574±2057	0.000	333±838	573±1578	0.007
Others	236±719	236±719	0.275	221±774	199±485	0.619
Direct non-medical costs	1225±1155	1100±1196	0.000	1191±905	1035±1094	0.026
Family caregiver transportation fare in hospitalization	243±276	243±276	0.014	234±216	247±261	0.433
Paid care cost in hospitalization	683±775	683±775	0.014	657±606	694±733	0.433
Doctor's labor cost	298±167	100±109	0.000	301±171	94±99	0.000
Indirect costs	17934±108137	27221±128328	0.006	20276±114665	10188±65615	0.114
Patient productivity loss according to LOS	693±996	662±926	0.254	642±704	734±1215	0.189
Family caregiver productivity loss according to LOS	1382±1569	1492±1623	0.014	1330±1226	1404±1484	0.433
Patient productivity loss according to ED-LOS	94±92	105±111	0.000	88±89	104±106	0.015
Patient productivity loss according to IHM	15766±107595	24961±127964	0.006	18217±114567	7945±65363	0.107

Data are presented as mean ± standard deviation. HG, hospitalist group; NHG, non-hospitalist group; ED-LOS, emergency department length of stay; LOS, length of hospital stay; IHM, in hospital mortality; KTAS, Korean Triage and Acuity Scale; Cost unit: USD (U.S. Dollar), ($1=1070.5 KRW, year: 2017)

Supplementary 4. Cost analysis for patients with different comorbidity severities treated by hospitalists or non-hospitalists (N=6391)

	ACCI: 0-2 (N=1747)			ACCI: 3 (N=1169)		
Cost per capita (USD)	**HG (n=729)**	**NHG (n=1018)**	***P* value**	**HG (n=436)**	**NHG (n=733)**	***P* value**
Total costs	20003±118820	35488±172186	0.036	29935±135536	41822±144012	0.163
Direct costs	4583±5747	5909±10111	0.001	5496±7177	7183±9436	0.001
Direct medical costs	3611±5114	5046±9305	0.000	4332±6230	6117±8476	0.000
Consultation fee	253±199	275±265	0.065	277±198	317±266	0.007
Admission fee	748±970	1040±1589	0.000	985±2267	1455±2272	0.001
Medication fee	817±2017	967±3591	0.308	1004±2683	1060±2413	0.712
Treatment and surgery fee	230±872	427±2642	0.053	233±588	559±1885	0.000
Medical examination fee	1182±1397	1603±1937	0.000	1352±1519	1905±2043	0.000
Therapeutic materials	276±749	605±1663	0.000	282±540	625±1429	0.000
Others	104±183	129±242	0.023	199±562	195±483	0.905
Direct non-medical costs	973±750	863±999	0.012	1164±1044	1067±1160	0.149
Family caregiver transportation fare in hospitalization	181±179	206±238	0.017	225±248	255±277	0.065
Paid care cost in hospitalization	508±504	578±670	0.017	631±697	715±778	0.065
Doctor's labor cost	283±146	78±91	0.000	308±184	97±106	0.000
Indirect costs	15420±117878	29579±169837	0.052	24439±133913	34638±142528	0.227
Patient productivity loss according to LOS	721±834	838±1229	0.026	734±995	714±1055	0.749
Family caregiver productivity loss according to LOS	1029±1020	1170±1356	0.017	1278±1411	1447±1574	0.065
Patient productivity loss according to ED-LOS	117±105	147±131	0.000	94±87	112±132	0.011
Patient productivity loss according to IHM	13553±117618	27424±169279	0.057	22334±133250	32365±142238	0.233

Supplementary 5. Cost analysis for patients with different comorbidity severities treated by hospitalists or non-hospitalists (N=6391)

	ACCI: 4 (N=1445)			ACCI: ≥5 (N=2030)		
Cost variable (USD)	**HG (n=502)**	**NHG (n=943)**	***P* value**	**HG (n=759)**	**NHG (n=1271)**	***P* value**
Total costs	16921±56921	26609±82829	0.019	30740±114253	30740±114253	0.757
Direct costs	5888±7505	7317±8745	0.002	8356±12175	8354±10421	0.997
Direct medical costs	4683±6785	6205±7858	0.000	6859±10889	7075±9321	0.635
Consultation fee	302±201	330±247	0.025	380±371	378±341	0.939
Admission fee	1074±1414	1493±2024	0.000	1466±2782	1666±2279	0.078
Medication fee	1132±3997	1068±2464	0.709	1430±2732	1211±2635	0.073
Treatment and surgery fee	205±454	486±1525	0.000	547±2135	622±2099	0.437
Medical examination fee	1496±1602	1958±2000	0.000	2055±2715	2128±2142	0.504
Therapeutic materials	306±712	685±1937	0.000	560±1576	751±1994	0.024
Others	169±341	185±379	0.428	421±1162	318±843	0.021
Direct non-medical costs	1205±888	1111±1065	0.092	1497±1476	1279±1374	0.001
Family caregiver transportation fare in hospitalization	238±209	265±254	0.038	312±353	305±328	0.643
Paid care cost in hospitalization	668±587	745±714	0.038	877±991	857±921	0.643
Doctor's labor cost	300±180	101±97	0.000	307±170	116±125	0.000
Indirect costs	11033±54908	19293±80063	0.039	22384±111513	20986±86969	0.753
Patient productivity loss according to LOS	511±739	505±570	0.863	735±1139	633±869	0.023
Family caregiver productivity loss according to LOS	1351±1188	1508±1445	0.038	1775±2006	1735±1864	0.643
Patient productivity loss according to ED-LOS	67±61	77±77	0.010	86±90	88±86	0.643
Patient productivity loss according to IHM	9105±54666	17203±79712	0.042	19787±110881	18530±86796	0.776

Data are presented as mean ± standard deviation. HG, hospitalist group; NHG, non-hospitalist group; ED-LOS, emergency department length of stay; LOS,

length of hospital stay; IHM, in hospital mortality; ACCI, Age-adjusted Charlson Comorbidity Index; Cost unit: USD (U.S. Dollar), ($1=1070.5 KRW, year: 2017)

Supplementary 5. Cost analysis according to major diseases between hospitalist and non-hospitalist groups (N=6391)

	Malignant neoplasms (N=1735)			Diseases of the circulatory system (N=600)		
Cost per capita (USD)	**HG (n=845)**	**NHG (n=890)**	***P* value**	**HG (n=48)**	**NHG (n=552)**	***P* value**
Total costs	44490±156505	76101±199695	0.000	25810±103615	12727±45059	0.096
Direct costs	7453±8256	8726±9323	0.003	6621±7677	7526±11864	0.604
Direct medical costs	6073±7384	7423±8443	0.000	5468±7155	6733±11030	0.435
Consultation fee	341±254	375±269	0.007	285±170	257±244	0.438
Admission fee	1302±1625	1655±1810	0.000	978±1023	1057±1850	0.772
Medication fee	1574±3576	1933±3647	0.039	984±2438	507±2209	0.156
Treatment and surgery fee	283±692	457±1540	0.003	467±1859	650±3247	0.700
Medical examination fee	1756±1862	2082±1862	0.001	1748±1605	2077±2164	0.303
Therapeutic materials	451±938	541±944	0.045	843±3480	2042±3805	0.035
Others	366±1033	380±997	0.780	163±232	143±376	0.710
Direct non-medical costs	1380±1053	1303±1121	0.141	1153±789	793±1029	0.018
Family caregiver transportation fare in hospitalization	284±249	311±268	0.028	223±173	189±245	0.357
Paid care cost in hospitalization	797±700	874±752	0.028	625±486	532±690	0.357
Doctor's labor cost	300±165	119±102	0.000	305±249	72±94	0.000
Indirect costs	37037±154884	67375±199297	0.000	19189±102860	5201±43086	0.066
Patient productivity loss according to LOS	859±1066	880±1019	0.674	649±834	439±795	0.082
Family caregiver productivity loss according to LOS	1613±1416	1768±1521	0.028	1265±983	1076±1396	0.357
Patient productivity loss according to ED-LOS	103±103	134±147	0.000	91±73	78±77	0.283
Patient productivity loss according to IHM	34462±154418	64593±199177	0.000	17184±102641	3607±43035	0.074

Supplementary 5. Costs analysis according to major diseases between hospitalist and non-hospitalist groups (N=6291)

	Diseases of the respiratory system (N=1141)			Diseases of the digestive system (N=865)		
Cost per capita (USD)	**HG (n=266)**	**NHG (n=875)**	***P* value**	**HG (n=441)**	**NHG (n=424)**	***P* value**
Total costs	14341±33698	21647±70991	0.105	12333±80610	23432±115109	0.100
Direct costs	7039±15706	7216±8429	0.811	4497±6214	5608±7606	0.019
Direct medical costs	5647±14057	5982±7408	0.610	3594±5627	4804±7047	0.005
Consultation fee	335±396	342±257	0.713	256±184	280±202	0.072
Admission fee	1536±4601	1764±2373	0.283	684±986	954±1406	0.001
Medication fee	793±1866	800±1322	0.947	667±1663	876±1970	0.092
Treatment and surgery fee	583±2813	586±1443	0.982	361±1249	503±1795	0.176
Medical examination fee	1842±3462	1891±2015	0.773	1157±1466	1527±1719	0.001
Therapeutic materials	336±1404	392±1055	0.486	369±728	568±1318	0.006
Others	223±605	206±396	0.609	100±370	97±160	0.866
Direct non-medical costs	1392±1795	1234±1180	0.094	903±724	803±731	0.044
Family caregiver transportation fare in hospitalization	283±432	295±282	0.617	169±174	192±175	0.060
Paid care cost in hospitalization	796±1214	827±791	0.617	476±490	539±490	0.060
Doctor's labor cost	313±179	112±107	0.000	258±100	73±67	0.000
Indirect costs	7302±25809	14431±69239	0.100	7836±77605	17824±112939	0.129
Patient productivity loss according to LOS	605±754	659±719	0.292	535±733	519±580	0.728
Family caregiver productivity loss according to LOS	1610±2457	16744±1601	0.617	963±992	1090±992	0.060
Patient productivity loss according to ED-LOS	74±67	81±75	0.176	95±92	133±124	0.000
Patient productivity loss according to IHM	5012±25287	12016±69041	0.105	6243±76629	16082±112722	0.132

Supplementary 5. Costs analysis according to major diseases between hospitalist and non-hospitalist groups (N=6291)

	Diseases of the genitourinary system (N=577)			Symptoms, signs and abnormal clinical and laboratory findings (N=329)		
Cost per capita (USD)	**HG (n=202)**	**NHG (n=375)**	***P* value**	**HG (n=162)**	**NHG (n=167)**	***P* value**
Total costs	16620±98690	13842±72463	0.700	7800±11363	12610±61380	0.327
Direct costs	5095±6616	5609±5862	0.338	5098±5326	4742±4662	0.519
Direct medical costs	3948±5768	4665±5147	0.127	4062±4766	4102±4239	0.935
Consultation fee	293±263	324±237	0.159	263±179	230±138	0.061
Admission fee	866±1310	1111±1524	0.054	815±1257	812±1096	0.978
Medication fee	595±1129	617±841	0.797	504±1066	332±1000	0.133
Treatment and surgery fee	306±1059	487±1175	0.069	233±1030	176±685	0.555
Medical examination fee	1478±1746	1648±1420	0.206	1742±1362	1926±1523	0.249
Therapeutic materials	258±905	322±816	0.391	350±726	542±839	0.027
Others	152±416	158±264	0.833	155±445	85±108	0.049
Direct non-medical costs	1147±915	943±808	0.006	1037±732	640±550	0.000
Family caregiver transportation fare in hospitalization	218±220	225±193	0.679	191±162	153±131	0.017
Paid care cost in hospitalization	612±619	632±542	0.679	538±455	429±368	0.017
Doctor's labor cost	318±171	86±74	0.000	307±217	58±50	0.000
Indirect costs	11524±98067	8233±72269	0.647	2701±9309	7868±60493	0.283
Patient productivity loss according to LOS	476±529	486±490	0.827	528±632	384±415	0.015
Family caregiver productivity loss according to LOS	1238±1252	1280±1097	0.679	1089±920	868±746	0.017
Patient productivity loss according to ED-LOS	76±69	88±73	0.061	91±85	80±70	0.201
Patient productivity loss according to IHM	9733±97932	6379±72352	0.640	995±9321	6536±60486	0.250

Supplementary 5. Costs analysis according to major diseases between hospitalist and non-hospitalist groups (N=6291)

	Certain infectious and parasitic diseases (N=290)			Endocrine, nutritional and metabolic diseases (N=253)		
Cost per capita (USD)	**HG (n=86)**	**NHG (n=204)**	***P* value**	**HG (n=95)**	**NHG (n=158)**	***P* value**
Total costs	6126±5154	26372±111599	0.094	16495±95205	6323±9347	0.183
Direct costs	4258±3834	7383±11679	0.016	4841±7708	4447±6963	0.676
Direct medical costs	3138±3131	6260±10687	0.008	3725±6559	3591±5971	0.868
Consultation fee	262±189	328±326	0.081	301±364	301±364	0.382
Admission fee	845±956	1774±2516	0.001	785±1072	943±1639	0.403
Medication fee	525±580	1233±4195	0.120	600±1858	408±902	0.272
Treatment and surgery fee	131±467	505±2175	0.116	339±1414	230±889	0.450
Medical examination fee	1068±998	1908±2394	0.002	1285±1626	1410±1825	0.582
Therapeutic materials	161±461	363±863	0.042	245±879	181±473	0.451
Others	144±209	148±209	0.890	169±455	151±412	0.745
Direct non-medical costs	1120±762	1123±1219	0.985	1116±1242	856±1036	0.073
Family caregiver transportation fare in hospitalization	211±181	268±291	0.096	212±299	204±247	0.818
Paid care cost in hospitalization	594±508	753±817	0.096	596±841	574±695	0.818
Doctor's labor cost	315±180	102±111	0.000	308±158	78±94	0.000
Indirect costs	1867±1395	18989±104949	0.132	11653±94525	1876±2502	0.194
Patient productivity loss according to LOS	581±477	725±1113	0.248	669±1717	605±1132	0.722
Family caregiver productivity loss according to LOS	1202±1029	1524±1653	0.096	1206±1702	1161±1406	0.818
Patient productivity loss according to ED-LOS	84±72	120±124	0.014	86±82	111±113	0.061
Patient productivity loss according to IHM	0	16620±103886	0.139	9693±94472	0	0.198

Supplementary 5. Costs analysis according to major diseases between hospitalist and non-hospitalist groups (N=6291)

	Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism (N=177)			Diseases of the musculoskeletal system and connective tissue (N=147)		
Cost per capita (USD)	**HG (n=130)**	**NHG (n=47)**	***P* value**	**HG (n=58)**	**NHG (n=89)**	***P* value**
Total costs	14823±68773	78742±287398	0.019	10444±14436	22650±48811	0.066
Direct costs	6070±10356	12352±20159	0.007	7613±11259	10391±16172	0.256
Direct medical costs	5004±9275	10886±18407	0.006	6000±9919	8392±13430	0.246
Consultation fee	264±265	454±499	0.001	389±396	527±711	0.181
Admission fee	996±1598	1829±2601	0.011	1368±1956	2051±3835	0.212
Medication fee	2262±5608	5095±10972	0.026	971±2231	1375±2668	0.340
Treatment and surgery fee	123±470	429±1357	0.027	485±2049	828±2651	0.405
Medical examination fee	1072±1779	2542±3572	0.000	1948±2545	2537±3011	0.221
Therapeutic materials	133±393	298±621	0.038	446±1450	678±1715	0.396
Others	155±300	238±395	0.136	393±1201	396±702	0.982
Direct non-medical costs	1066±1159	1467±1865	0.001	1613±1490	1999±2899	0.351
Family caregiver transportation fare in hospitalization	201±280	350±445	0.009	327±351	477±692	0.128
Paid care cost in hospitalization	566±787	983±1250	0.009	917±987	1340±1944	0.128
Doctor's labor cost	299±147	133±170	0.000	369±308	182±264	0.000
Indirect costs	8753±66519	66390±275040	0.027	2831±3318	12260±37835	0.061
Patient productivity loss according to LOS	614±1056	1326±2366	0.006	885±1437	1189±1468	0.218
Family caregiver productivity loss according to LOS	1145±1593	1990±2530	0.009	1857±1998	2712±3934	0.128
Patient productivity loss according to ED-LOS	93±75	97±84	0.760	89±88	116±118	0.149
Patient productivity loss according to IHM	6902±65811	62978±272001	0.030	0	8243±35817	0.082

Supplementary 5. Costs analysis according to major diseases between hospitalist and non-hospitalist groups (N=6291)

	Others (N=277)		
Cost per capita (USD)	**HG (n=93)**	**NHG (n=184)**	***P* value**
Total costs	22861±129109	33371±141104	0.548
Direct costs	7009±7284	8562±14556	0.334
Direct medical costs	5575±6273	7242±13280	0.253
Consultation fee	337±309	399±456	0.238
Admission fee	1139±1185	1713±2917	0.070
Medication fee	1617±3111	1475±3315	0.732
Treatment and surgery fee	266±822	855±4645	0.226
Medical examination fee	1585±1534	2071±2527	0.090
Therapeutic materials	422±1203	512±1393	0.597
Others	210±350	218±369	0.869
Direct non-medical costs	1434±1220	1320±1612	0.549
Family caregiver transportation fare in hospitalization	294±299	315±385	0.646
Paid care cost in hospitalization	826±839	885±1081	0.646
Doctor's labor cost	314±140	120±147	0.000
Indirect costs	15852±127947	24809±136150	0.598
Patient productivity loss according to LOS	857±1035	962±1849	0.612
Family caregiver productivity loss according to LOS	1671±1698	1790±2187	0.646
Patient productivity loss according to ED-LOS	100±127	124±114	0.111
Patient productivity loss according to IHM	13224±127529	21933±135026	0.606

Data are presented as mean ± standard deviation. HG, hospitalist group; NHG, non-hospitalist group; ED-LOS, emergency department length of stay; LOS,

length of hospital stay; IHM, in hospital mortality; Cost unit: USD (U.S. Dollar), ($1=1070.5 KRW, year: 2017)

Supplementary 6. Cost analysis according to age between hospitalist and non-hospitalist groups (N=6391)

	Age < 50yrs (N=1098)			Age : 50-59yrs (N=900)		
Cost per capita (USD)	**HG (n=488)**	**NHG (n=610)**	***P* value**	**HG (n=401)**	**NHG (n=499)**	***P* value**
Total costs	41296±190798	55982±228897	0.256	43701±158942	80904±219290	0.004
Direct costs	5537±8024	6382±11606	0.172	6335±7699	7852±10437	0.015
Direct medical costs	4414±7103	5435±10664	0.070	5118±6808	6766±9428	0.003
Consultation fee	279±268	290±283	0.508	301±256	329±320	0.151
Admission fee	943±1676	1187±1990	0.030	1004±1254	1333±1881	0.003
Medication fee	1100±2312	1138±3614	0.840	1333±3165	1538±4070	0.407
Treatment and surgery fee	270±1267	491±3229	0.155	264±667	529±1809	0.006
Medical examination fee	1292±1774	1665±2267	0.003	1556±1806	2009±2151	0.001
Therapeutic materials	312±873	500±1586	0.019	383±841	777±1627	0.000
Others	218±756	164±357	0.118	277±862	250±758	0.611
Direct non-medical costs	1122±1055	947±1111	0.008	1217±1013	1086±1277	0.096
Family caregiver transportation fare in hospitalization	217±252	226±265	0.573	241±243	259±305	0.327
Paid care cost in hospitalization	610±708	635±745	0.573	677±682	728±856	0.327
Doctor's labor cost	295±166	86±101	0.000	299±158	99±116	0.000
Indirect costs	35760±188566	49600±226007	0.279	37366±157428	73052±217444	0.006
Patient productivity loss according to LOS	1012±1411	1048±1423	0.673	1190±1249	1291±1588	0.298
Family caregiver productivity loss according to LOS	1235±1433	1285±1507	0.573	1370±1380	1474±1732	0.327
Patient productivity loss according to ED-LOS	132±110	168±150	0.000	155±124	208±168	0.000
Patient productivity loss according to IHM	33382±187835	47099±225426	0.281	34651±156938	70079±217136	0.006

Supplementary 6. Cost analysis according to age between hospitalist and non-hospitalist groups (N=6391)

	Age : 60-69yrs (N=1275)			Age : 70-79yrs (N=1763)		
Cost per capita (USD)	**HG (n=542)**	**NHG (n=733)**	***P* value**	**HG (n=632)**	**NHG (n=1131)**	***P* value**
Total costs	16962±43491	26750±54996	0.001	13784±27205	18436±34130	0.003
Direct costs	5944±7639	7909±10615	0.000	6812±11712	7523±10269	0.186
Direct medical costs	4783±6983	6741±9593	0.000	5498±10457	6393±9222	0.063
Consultation fee	293±197	349±311	0.000	323±280	338±300	0.300
Admission fee	1045±1425	1476±2092	0.000	1251±3122	1464±2251	0.098
Medication fee	1136±3927	1383±3514	0.239	1102±2467	1000±2127	0.359
Treatment and surgery fee	277±976	555±2052	0.004	414±1962	616±2248	0.058
Medical examination fee	1478±1656	2032±2122	0.000	1741±2608	2004±2224	0.025
Therapeutic materials	336±808	685±1485	0.000	402±1188	742±2091	0.000
Others	219±666	262±701	0.264	266±819	228±609	0.269
Direct non-medical costs	1161±833	1168±1302	0.910	1314±1369	1130±1270	0.005
Family caregiver transportation fare in hospitalization	227±195	279±311	0.001	265±327	270±303	0.750
Paid care cost in hospitalization	636±548	783±873	0.001	744±920	758±852	0.750
Doctor's labor cost	298±172	106±118	0.000	305±182	103±116	0.000
Indirect costs	11018±40113	18842±51892	0.004	6973±21476	10913±30046	0.004
Patient productivity loss according to LOS	426±409	515±569	0.002	470±558	488±581	0.526
Family caregiver productivity loss according to LOS	1288±1109	1585±1767	0.001	1505±1862	1533±1724	0.750
Patient productivity loss according to ED-LOS	64±55	80±68	0.000	66±58	73±58	0.011
Patient productivity loss according to IHM	9240±39727	16662±51527	0.005	4932±20981	8819±29646	0.004

Supplementary 6. Cost analysis according to age between hospitalist and non-hospitalist groups (N=6391)

	Age ≥ 80yrs (N=1355)		
Cost per capita (USD)	**HG (n=363)**	**NHG (n=992)**	***P* value**
Total costs	10683±15847	14300±19144	0.001
Direct costs	6243±7253	6735±6609	0.238
Direct medical costs	4968±6284	5648±5809	0.062
Consultation fee	345±348	328±246	0.298
Admission fee	1122±1399	1536±1976	0.000
Medication fee	836±1711	708±1135	0.111
Treatment and surgery fee	381±1053	430±854	0.377
Medical examination fee	1670±1607	1821±1503	0.109
Therapeutic materials	440±1496	646±1871	0.059
Others	174±347	179±378	0.810
Direct non-medical costs	1275±1188	1087±963	0.003
Family caregiver transportation fare in hospitalization	258±285	259±230	0.903
Paid care cost in hospitalization	724±801	729±646	0.903
Doctor's labor cost	294±150	99±88	0.000
Indirect costs	4440±11651	7565±16499	0.001
Patient productivity loss according to LOS	445±504	449±431	0.886
Family caregiver productivity loss according to LOS	1465±1620	1475±1307	0.903
Patient productivity loss according to ED-LOS	61±47	68±52	0.026
Patient productivity loss according to IHM	2469±11331	5573±16326	0.001

Data are presented as mean ± standard deviation. HG, hospitalist group; NHG, non-hospitalist group; ED-LOS, emergency department length of stay; LOS,

length of hospital stay; IHM, in hospital mortality; Cost unit: USD (U.S. Dollar), ($1= 1070.5 KRW, year: 2017)

Supplementary 7. Natural log-transformed multivariate regression analysis for medical costs and total costs (N=6791)

Variables	Ln(medical costs)			Ln(total costs)		
	coefficient	SE	*P* value	coefficient	SE	*P* value
(constant)	14.601	0.030	0.000	15.563	0.031	0.000
HG (ref= NHG)	-0.355	0.016	0.000	-0.279	0.016	0.000
Female (ref= male)	-0.063	0.012	0.000	-0.091	0.012	0.000
Age	0.001	0.000	0.001	0.004	0.000	0.000
ACCI	0.019	0.003	0.000	0.013	0.003	0.000
KTAS[a] (ref= more urgency)	-0.054	0.018	0.003	-0.027	0.018	0.133
Prior hospitalization history	-0.002	0.001	0.247	0.005	0.001	0.002
LOS	0.034	0.001	0.000	0.036	0.001	0.000
ED-LOS	0.006	0.001	0.000	0.007	0.001	0.000
CPR (ref = No)	-0.170	0.071	0.016	0.030	0.072	0.675
ICU admission (ref = No)	0.711	0.027	0.000	0.819	0.027	0.000
Referral to specialty (ref = No)	0.391	0.017	0.000	0.370	0.017	0.000
Consultation	0.007	0.002	0.000	-0.004	0.002	0.035
IHM	0.127	0.024	0.000	2.879	0.025	0.000
Surgical intervention (ref = No)	0.282	0.019	0.000	0.213	0.020	0.000
Major diseases (ref= malignant neoplasms)						
Circulatory system	-0.031	0.025	0.220	-0.117	0.026	0.000
Respiratory system	-0.162	0.020	0.000	-0.184	0.021	0.000
Digestive system	-0.166	0.021	0.000	-0.223	0.022	0.000
Genitourinary system	-0.199	0.024	0.000	-0.103	0.025	0.000
Symptoms, signs and abnormal clinical and laboratory findings	-0.068	0.030	0.022	-0.153	0.030	0.000
Certain infectious and parasitic diseases	-0.207	0.031	0.000	-0.220	0.032	0.000
Endocrine, nutritional and metabolic diseases	-0.330	0.033	0.000	-0.278	0.033	0.000
Diseases of the blood and blood- forming organs and certain disorders involving the immune mechanism	-0.062	0.038	0.103	-0.155	0.039	0.000
Diseases of the musculoskeletal system and connective tissue	-0.326	0.042	0.000	-0.305	0.042	0.000
Others	-0.200	0.032	0.000	-0.184	0.032	0.000
	Adj- R2 = 0.686, F = 583.730 (*p* = 0.000)			Adj- R2 = 0.823, F = 1237.996 (*p* = 0.000)		

HG, hospitalist group; NHG, non-hospitalist group; ACCI, Age-adjusted Charlson Comorbidity Index; KTAS, Korean Triage and Acuity Scale; CPR, Cardio-pulmonary resuscitation; IHM, in-hospital mortality; ICU, intensive care unit; LOS, length of hospital stay; ED-LOS, emergency department length of stay; SE, standard error

"surgical intervention" implies the patient underwent surgery during the hospital stay, not before.

[a]the less urgent group with KTAS = 4–5 was compared to the more urgent group with KTAS = 1–3.

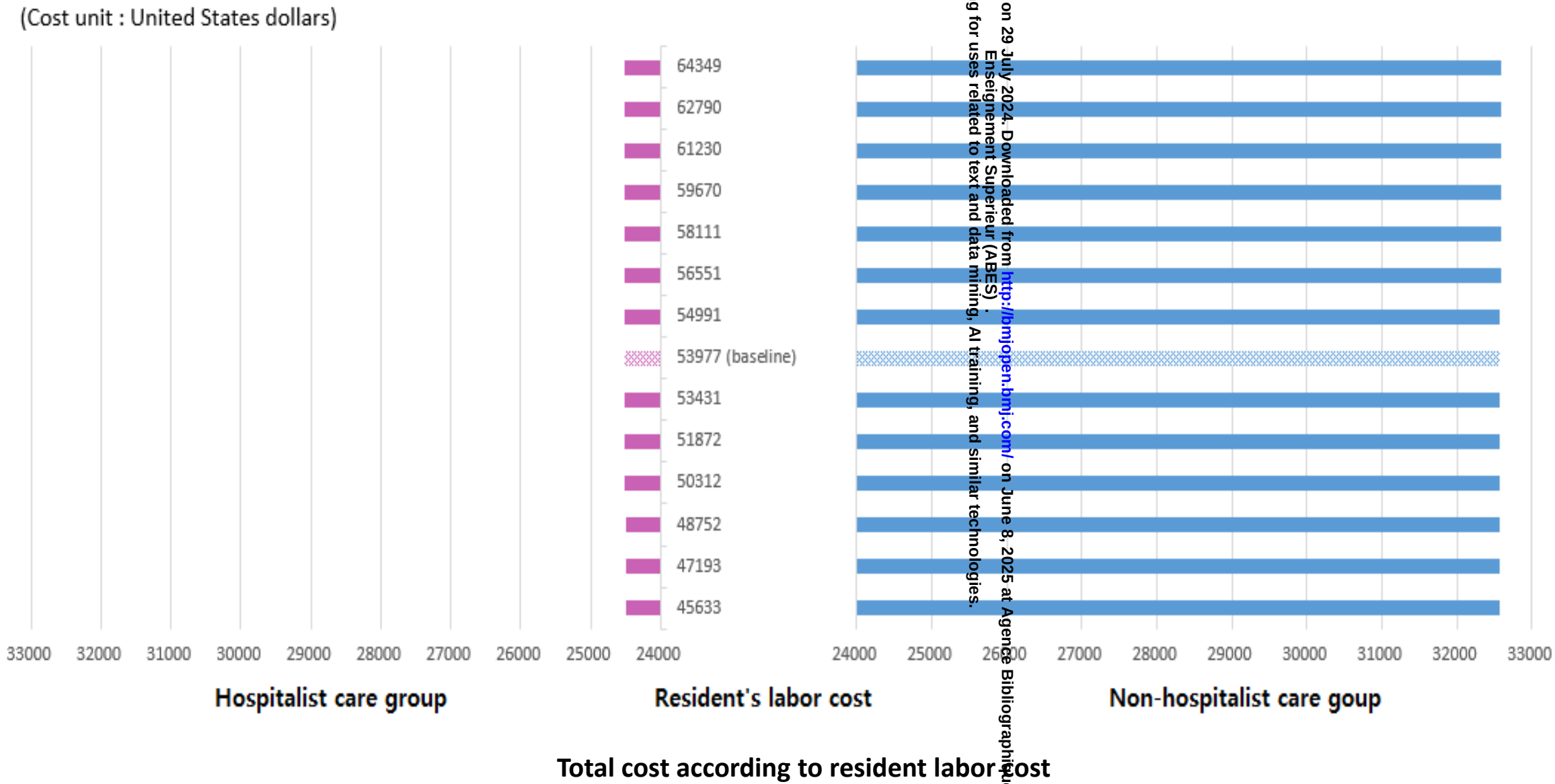
Supplementary 8. Natural log-transformed multivariate regression analysis for direct costs and indirect costs (N=639)

Variables	Ln(direct costs)			Ln(indirect costs)		
	coefficient	SE	*P* value	coefficient	SE	*P* value
(constant)	14.821	0.027	0.000	14.542	0.030	0.000
HG (ref= NHG)	-0.240	0.015	0.000	-0.215	0.016	0.000
Female (ref= male)	-0.054	0.011	0.000	-0.026	0.012	0.000
Age	0.001	0.000	0.002	0.009	0.000	0.000
ACCI	0.018	0.003	0.000	0.004	0.003	0.229
KTAS[a] (ref= more urgency)	-0.039	0.016	0.016	-0.040	0.017	0.651
Prior hospitalization history	-0.001	0.001	0.462	0.001	0.001	0.000
LOS	0.037	0.001	0.000	0.041	0.001	0.000
ED-LOS	0.005	0.001	0.000	0.001	0.001	0.000
CPR (ref = No)	-0.181	0.064	0.005	-0.200	0.069	0.004
ICU admission (ref = No)	0.633	0.024	0.000	0.040	0.026	0.127
Referral to specialty (ref = No)	0.336	0.015	0.000	0.294	0.017	0.000
Consultation	0.004	0.002	0.006	0.010	0.002	0.000
IHM	0.082	0.022	0.000	0.199	0.024	0.000
Surgical intervention (ref = No)	0.246	0.017	0.000	0.095	0.019	0.000
Major diseases (ref= malignant neoplasms)						
Circulatory system	-0.048	0.023	0.038	0.228	0.025	0.000
Respiratory system	-0.132	0.018	0.000	0.000	0.020	0.000
Digestive system	-0.159	0.019	0.000	0.215	0.021	0.000
Genitourinary system	-0.164	0.022	0.000	0.035	0.024	0.000
Symptoms, signs and abnormal clinical and laboratory findings	-0.076	0.027	0.005	0.200	0.029	0.000
Certain infectious and parasitic diseases	-0.166	0.028	0.000	0.174	0.031	0.000
Endocrine, nutritional and metabolic diseases	-0.276	0.030	0.000	0.133	0.032	0.000
Diseases of the blood and blood- forming organs and certain disorders involving the immune mechanism	-0.074	0.035	0.032	0.153	0.037	0.000
Diseases of the musculoskeletal system and connective tissue	-0.262	0.038	0.000	-0.133	0.041	0.000
Others	-0.159	0.029	0.000	-0.069	0.031	0.027
	Adj- R2 = 0.707, F = 644.685 (p = 0.000)			Adj- R2 = 0.891, F = 2173.571 (p = 0.000)		

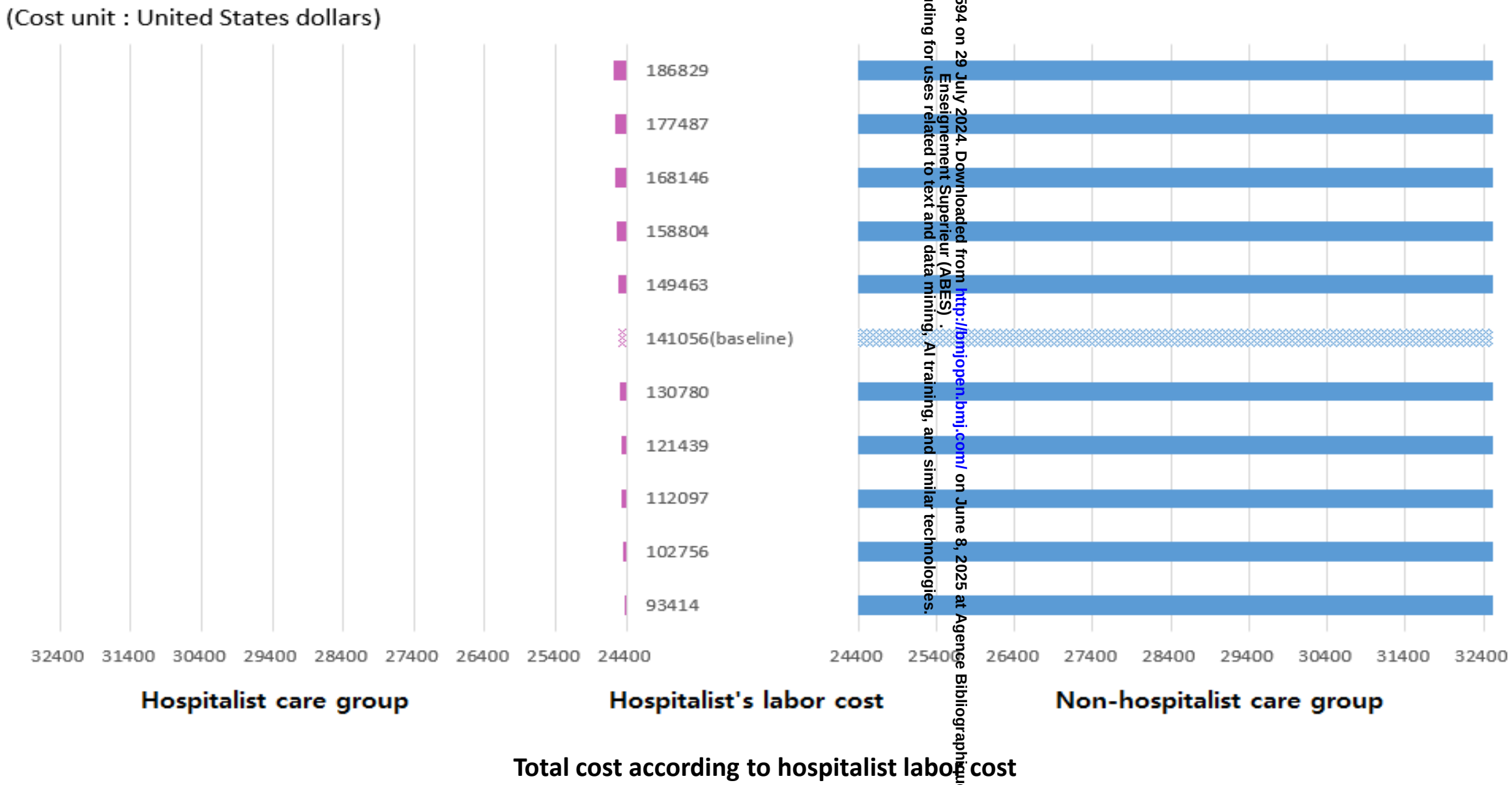
HG, hospitalist group; NHG, non-hospitalist group; ACCI, Age-adjusted Charlson Comorbidity Index; KTAS, Korean Triage and Acuity Scale; CPR, Cardio-pulmonary resuscitation; IHM, in-hospital mortality; ICU, intensive care unit; LOS, length of hospital stay; ED-LOS, emergency department length of stay; SE, standard error

"surgical intervention" implies the patient underwent surgery during the hospital stay, not before.

[a]the less urgent group with KTAS = 4–5 was compared to the more urgent group with KTAS = 1–3.



Supplementary 9. One-way sensitivity analysis for the resident labor cost



Supplementary 10. One-way sensitivity analysis for the hospitalist labor cost

Supplementary 11. Two-way sensitivity analysis of net benefit per capita according to doctor labor cost (N=6391)

		Hospitalist labor cost per doctor										
		93414	102756	112097	121439	130780	141056 (baseline)	149463	158804	168146	177487	186829
Resident labor cost per doctor	45633	8140	8125	8109	8094	8079	8062	8048	8032	8017	8002	7986
	47193	8141	8126	8110	8095	8080	8063	8049	8033	8018	8003	7987
	48752	8142	8127	8111	8096	8081	8064	8050	8034	8019	8004	7988
	50312	8143	8128	8112	8097	8082	8065	8051	8035	8020	8005	7989
	51872	8144	8129	8113	8098	8082	8066	8052	8036	8021	8005	7990
	53431	8145	8130	8114	8099	8083	8066	8053	8037	8022	8006	7991
	53977 (baseline)	8145	8130	8115	8099	8084	8067	8053	8038	8022	8007	7991
	54991	8146	8131	8115	8100	8084	8067	8054	8038	8023	8007	7992
	56551	8147	8132	8116	8101	8085	8068	8055	8039	8024	8008	7993
	58111	8148	8133	8117	8102	8086	8069	8056	8040	8025	8009	7994
	59670	8149	8133	8118	8103	8087	8070	8056	8041	8026	8010	7995
	61230	8150	8134	8119	8104	8088	8071	8057	8042	8027	8011	7996
	62790	8151	8135	8120	8105	8089	8072	8058	8043	8028	8012	7997
	64349	8152	8136	8121	8106	8090	8073	8059	8044	8029	8013	7998

Cost unit: USD (U.S. Dollar), ($1= 1070.5 KRW, year: 2017)

CHEERS 2022 Checklist

Topic	No.	Item	Location where item is reported
Title			
	1	Identify the study as an economic evaluation and specify the interventions being compared.	1
Abstract			
	2	Provide a structured summary that highlights context, key methods, results, and alternative analyses.	2
Introduction			
Background and objectives	3	Give the context for the study, the study question, and its practical relevance for decision making in policy or practice.	4
Methods			
Health economic analysis plan	4	Indicate whether a health economic analysis plan was developed and where available.	5
Study population	5	Describe characteristics of the study population (such as age range, demographics, socioeconomic, or clinical characteristics).	5
Setting and location	6	Provide relevant contextual information that may influence findings.	5
Comparators	7	Describe the interventions or strategies being compared and why chosen.	6
Perspective	8	State the perspective(s) adopted by the study and why chosen.	4,5
Time horizon	9	State the time horizon for the study and why appropriate.	10
Discount rate	10	Report the discount rate(s) and reason chosen.	10
Selection of outcomes	11	Describe what outcomes were used as the measure(s) of benefit(s) and harm(s).	6
Measurement of outcomes	12	Describe how outcomes used to capture benefit(s) and harm(s) were measured.	6-8
Valuation of outcomes	13	Describe the population and methods used to measure and value outcomes.	6-8
Measurement and valuation of resources and costs	14	Describe how costs were valued.	8-10
Currency, price date, and conversion	15	Report the dates of the estimated resource quantities and unit costs, plus the currency and year of conversion.	8,13

Topic	No.	Item	Location where item is reported
Rationale and description of model	16	If modelling is used, describe in detail and why used. Report if the model is publicly available and where it can be accessed.	Not applicable
Analytics and assumptions	17	Describe any methods for analysing or statistically transforming data, any extrapolation methods, and approaches for validating any model used.	11,12
Characterising heterogeneity	18	Describe any methods used for estimating how the results of the study vary for subgroups.	7,8
Characterising distributional effects	19	Describe how impacts are distributed across different individuals or adjustments made to reflect priority populations.	10,11
Characterising uncertainty	20	Describe methods to characterise any sources of uncertainty in the analysis.	10,11
Approach to engagement with patients and others affected by the study	21	Describe any approaches to engage patients or service recipients, the general public, communities, or stakeholders (such as clinicians or payers) in the design of the study.	12
Results			
Study parameters	22	Report all analytic inputs (such as values, ranges, references) including uncertainty or distributional assumptions.	13-28
Summary of main results	23	Report the mean values for the main categories of costs and outcomes of interest and summarise them in the most appropriate overall measure.	13-18
Effect of uncertainty	24	Describe how uncertainty about analytic judgments, inputs, or projections affect findings. Report the effect of choice of discount rate and time horizon, if applicable.	18
Effect of engagement with patients and others affected by the study	25	Report on any difference patient/service recipient, general public, community, or stakeholder involvement made to the approach or findings of the study	Not applicable
Discussion			
Study findings, limitations, generalisability, and current knowledge	26	Report key findings, limitations, ethical or equity considerations not captured, and how these could affect patients, policy, or practice.	18-22
Other relevant information			
Source of funding	27	Describe how the study was funded and any role of the funder in the identification, design, conduct, and reporting of the analysis	22
Conflicts of interest	28	Report authors conflicts of interest according to journal or International Committee of Medical Journal Editors requirements.	22

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Economic evaluation of the hospitalist care model in an acute medical unit: A benefit-cost analysis

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Economic evaluation of the hospitalist care model in an acute medical unit: A benefit-cost analysis

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Keywords: acute medical unit, hospitalists, cost, benefit, benefit-cost, net-benefit, benefit cost ratio, economic evaluation

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Word count of the abstract: 275 words.

ABSTRACT

Objective: This study aimed to assess the economic efficiency of the acute medical unit (AMU) hospitalist care model, utilizing patient outcomes (length of hospital stay, emergency department-length of hospital stay, in hospital mortality) from a previous investigation.

Design: A retrospective cohort study was conducted using benefit-cost analysis from a societal perspective. Data relating to clinical factors, outcomes, and medical costs were obtained from the electronic medical record database at our institution. Literature-based costing was applied to determine direct non-medical costs and indirect costs that could not be obtained directly.

Setting: A tertiary care hospital in the Republic of Korea.

Participants: We evaluated 6391 medical inpatients admitted through the emergency department (ED) from June 1, 2016, to May 31, 2017.

Interventions: The study compared multiple types of costs and benefits among inpatients from the ED between a non-hospitalist group and an AMU hospitalist group.

Results: This investigation found a significant 30% reduction in medical costs and a 29.3% reduction in total costs in the AMU hospitalist group compared to the non-hospitalist group ($e^{-0.355}$=0.701, *P*=0.000; $e^{-0.346}$=0.707, *P*=0.000; respectively). Furthermore, significant reductions in direct and indirect costs of 28.6% and 23.3% were found in the AMU hospitalist group compared to the non-hospitalist group **(**$e^{-0.336}$=0.714, *P*=0.000; $e^{-0.265}$=0.767, *P*=0.000; respectively). The net-benefit and benefit-cost ratio (BCR) of the AMU hospitalist care group were US $6846 and 1.33 per patient admission, respectively.

Conclusions: The AMU hospitalist care model was associated with remarkable reductions in multiple costs. The results of the sensitivity analysis indicated that the net-benefit estimates of AMU hospitalist care were similar to the baseline estimates. Thus, the overall net-benefit of AMU hospitalist care was found to be largely positive.

Strengths and limitations of this study

- In this study, extensive cost analysis was conducted from a societal perspective.
- The study encompassed all medical inpatients who were admitted from the emergency department to medical wards throughout the specified time frame of June 1, 2016, to May 31, 2017. Having such broad inclusion criteria is likely to have enhanced the validity of the findings.
- Making generalizations regarding this retrospective study is challenging because of its singular institution of origin.
- Expenditures apart from medical costs were not obtained directly but were calculated after consulting relevant sources; therefore, there may be a degree of uncertainty in the cost estimates.
- This study could not quantify the potential benefits associated with a reduction in admissions to the intensive care unit. Therefore, it is possible that the benefits determined in this study were undervalued.

INTRODUCTION

In South Korea, a pilot hospitalist care system was implemented from 2016 to address reduced numbers of medical personnel and improve the quality of inpatient care [1]. The pilot project was integrated within the general hospital care system after 5 years and the number of hospitalists in Korea has increased to approximately 250 [2]. Under the hospitalist care model, a dedicated specialist takes comprehensive responsibility directly and provides managed care to patients during admission, whereas under the non-hospitalist care model, a resident provides care to patients during admission under the supervision of a specialist.

Since the implementation of the hospitalist care system in Korea, research on patient outcomes has been conducted [3-9] in terms of in-hospital mortality (IHM), intensive care unit (ICU) admission, emergency department-length of stay (ED-LOS), and total length of stay (LOS). Although there have been many studies on the effectiveness of the hospitalist system, few studies have been undertaken on costs or involving economic evaluations. While some studies have reported on the medical costs of hospitalist care in South Korea [7, 10], no economic evaluations from a societal perspective have been reported concerning hospitalist care in South Korea. Therefore, it is necessary to evaluate the economic efficiency of hospitalist care considering both its costs and effects in terms of whether it is efficient within the overall medical system. In this study, economic efficiency was defined by a positive net-benefit and benefit-cost ratio (BCR) exceeding 1. Hence, we conducted an economic evaluation that accounted for both costs and benefits for the same patient population whose outcomes had been previously assessed [9].

In this study, a societal-perspective economic evaluation was conducted to estimate the overall costs and benefits of the acute medical unit (AMU) hospitalist care model implemented at our institution, based on patient outcomes. We aimed to provide new evidence on the economic efficiency of the AMU hospitalist care model.

METHODS

Study participants and AMU setting

We evaluated 6391 medical inpatients admitted through the emergency department (ED) of our institution from June 1, 2016, to May 31, 2017, who were assigned to AMU hospitalist care and non-hospitalist care groups (2426 and 3965 patients, respectively). The AMU patients were evaluated and treated by four hospitalists with an average of ten years of clinical experience in infectious diseases, pulmonology and critical care, nephrology, and endocrinology [9]. Seven days per week, two AMU hospitalists were responsible for the care of the AMU patients admitted during the day. In addition, non-hospitalist inpatient care was provided by subspecialists and residents in a specialty medical ward, where residents were primarily responsible for inpatient care under the supervision of an attending physician [9]. While hospitalist care in the AMU focused on general acute care, non-hospitalist care in the specialty medical ward emphasized long-term and specialized treatment [9].

Study design

This retrospective cohort study compared and analyzed the cost-saving benefits, calculated based on costs and patient outcomes, between AMU hospitalist care and non-hospitalist care groups for patients admitted through the ED at a tertiary hospital.

We conducted a benefit-cost analysis and divided costs into medical costs, non-medical costs, and time costs in terms of productivity loss [11]. This investigation was conducted in accordance with Consolidated Health Economic Evaluation Reporting Standards 2022 (CHEERS 2022) [12]. A flow diagram of the study population and benefit-cost factors is presented in Supplementary 1.

Ethics statement

The study protocol was approved by the Institutional Review Board of Seoul National University Bundang Hospital (approval number: B-1711/435-107) and the need for informed consent was waived.

Outcomes and clinical variables

Outcomes and clinical variables were obtained from the electronic medical records (EMRs) at our institution. Among the outcome variables, IHM, LOS, and ED-LOS were used to calculate costs and benefits as well as the time cost of productivity loss. Productivity loss is the time cost incurred as a result of mortality or disease-related restrictions on productive activities due to admission [13].

We analyzed the following clinical variables of the participants: age, sex, prior hospitalization history, cardiopulmonary resuscitation (CPR) incidence, cause of ICU admission, referral to a specialty, consultations, surgical intervention (cases performed during the hospitalization, not before), major diagnosis (based on the International Statistical Classification of Diseases and Related Health Problems, 10th Revision, Australian Modification [ICD-10-AM]), and Korean Triage and Acuity Scale (KTAS), Age-adjusted Charlson Comorbidity Index (ACCI), and Acute Physiology and Chronic Health Evaluation (APACHE) II scores. The ACCI score is derived from the sum of 1, 2, 3, and 6 weighted values for 17 disease groups, ranging from 0 to 29; higher scores indicate higher severity [14]. The KTAS, which is currently applied in emergency medical centers in Korea, is a national standardized classification tool for evaluating illness severity [15]. We used the APACHE II score to compare the disease severity among ICU admissions; this score (range: 0–71) has been found to closely correlate with the risk of hospital death [16]. Baseline characteristics of the study population are presented in Table 1 [9].

Table 1. Baseline characteristics of patients cared for by hospitalists and non-hospitalists (N=6391)

Baseline Characteristics	Hospitalists (n=2426)	Non-hospitalists (n=3965)	*P value*
Sex			
Male	1387 (57.2)	2188 (55.2)	0.120
Female	1039 (42.8)	1777 (44.8)	
Age (years)	63.24±16.20	67.38±16.52	<0.001
<50	488 (20.1)	610 (15.4)	<0.001
50–59	401 (16.5)	499 (12.6)	
60–69	542 (22.3)	733 (18.5)	
70–79	632 (26.1)	1131 (28.5)	
≥80	363 (15.0)	992 (25.0)	
Prior hospitalization	2101 (86.6)	3373 (85.1)	0.090
Number of prior hospitalizations	3.16±4.07	3.24±4.20	0.480
Korean Triage and Acuity Scale			
1 (Resuscitation)	12 (0.5)	69 (1.7)	<0.001
2 (Emergency)	324 (13.4)	941 (23.7)	
3 (Urgent)	1699 (70.0)	2511 (63.3)	
4 (Less urgent)	367 (15.1)	403 (10.2)	
5 (Non-urgent)	24 (1.0)	41 (1.0)	
Major disease			
Malignant neoplasms	845 (34.8)	890 (22.4)	<0.001
Diseases of the circulatory system	48 (2.0)	552 (13.9)	
Diseases of the respiratory system	266 (11.0)	875 (22.1)	
Diseases of the digestive system	441 (18.2)	424 (10.7)	
Diseases of the genitourinary system	202 (8.3)	375 (9.5)	
Symptoms, signs, and abnormal clinical and laboratory findings	162 (6.7)	167 (4.2)	
Certain infectious and parasitic diseases	86 (3.5)	204 (5.1)	
Endocrine, nutritional, and metabolic diseases	95 (3.9)	158 (4.0)	
Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism	130 (5.4)	47 (1.2)	
Diseases of the musculoskeletal system and connective tissue	58 (2.4)	89 (2.2)	
Others	93 (3.8)	184 (4.6)	
Age-adjusted Charlson Comorbidity Index	3.82±2.63	3.77±2.19	
Median [IQR]	4 [2–5]	4 [2–5]	0.055
≤2	729 (30.0)	1018 (25.7)	0.001
3	436 (18.0)	733 (18.5)	
4	502 (20.7)	943 (23.8)	
≥5	759 (31.3)	1271 (32.1)	
Surgical intervention	282 (11.6)	560 (14.1)	0.004
CPR incidence	15 (0.6)	35 (0.9)	0.244
Consultation	1830 (75.4)	2946 (74.3)	0.312

Baseline Characteristics	Hospitalists (n=2426)	Non-hospitalists (n=3965)	*P value*
Number of consultations	3.50±6.18	3.99±7.02	0.004
Referral to a specialty	1613 (66.5)	450 (11.3)	<0.001
Type of specialty referral (n=2063)			
Hematology & Oncology	658 (40.8)	114 (25.3)	<0.001
Gastroenterology	360 (22.3)	20 (4.4)	
Respiratory	174 (10.8)	53 (11.8)	
Nephrology	96 (6.0)	11 (2.4)	
Infection	96 (6.0)	8 (1.8)	
Geriatrics	80 (5.0)	9 (2.0)	
Others	149 (9.2)	235 (52.2)	
Outcomes			
In-hospital mortality	117 (4.8)	361 (9.1)	<0.001
ICU admission	95 (3.9)	343 (8.7)	<0.001
Cause of ICU admission (n=438)			
Close monitoring after procedure or surgical intervention	55 (57.9)	223 (65.0)	0.077
Respiratory failure or insufficiency	23 (24.2)	78 (22.7)	
Septic shock	7 (7.4)	17 (5.0)	
Cardiovascular failure or insufficiency	7 (7.4)	12 (3.5)	
Metabolic/Renal failure	0 (0.0)	8 (2.3)	
GI bleeding	3 (3.2)	2 (0.6)	
Neurogenic dysfunction	0 (0.0)	3 (0.9)	
APACHE II score at ICU admission (n=438)	25.20±10.62	21.26±12.03	0.004
Length of hospital stay (days)	10.56±11.68	11.40±12.36	
Median [IQR]	7 [4–12]	8 [5–13]	0.007
ED-LOS (hours)	11.24±8.49	13.74±10.11	
Median [IQR]	8.4 [6.1–12.7]	10.2 [6.7–19.0]	<0.001
Re-admission within 10 days	117 (4.8)	177 (4.5)	0.507
Re-admission within 30 days	277 (11.4)	416 (10.5)	0.248

Data are presented as the mean ± standard deviation, number (%), or median [IQR], as indicated.
"Surgical intervention" implies the patient underwent surgery during the hospital stay, not before.
IQR, interquartile range; CPR, cardiopulmonary resuscitation; ICU, intensive care unit; APACHE, Acute Physiology and Chronic Health Evaluation; ED-LOS, emergency department-length of stay

Cost measures

Micro-costing and gross-costing were used for cost calculation in this study. Micro-costing was applied to directly calculate the medical costs during the total hospital stay [17]. Gross-costing was used to calculate all costs other than medical costs (Supplementary 2). The costs were classified into direct

costs and indirect costs [13], with all unit costs converted to United States (US) dollars as of 2023.

Direct costs

Direct costs comprised medical costs (micro-costing), family caregiver transportation fares, paid care costs, and doctor labor costs in hospitalization (gross-costing). Healthcare in South Korea is a single-payer system organized through the National Health Insurance Service (NHIS). Nearly all citizens receive universal medical care through this system [18]. The governance of National Health Insurance in South Korea is presented in Supplementary 3. The health security system in Korea has two components: mandatory social health insurance and medical aid. In Korea, fee-for-service has been the standard payment model for outpatient care and the majority of inpatient care, leading to an increase in the volume of services that healthcare professionals can provide [19]. Medical costs in this study comprised reimbursements issued to medical providers by the NHIS and co-payments paid to medical providers by patients.

Medical cost data were obtained from hospital administrative information in the EMRs at our institution regarding consultation fee, admission fee (mainly hospital room expense, including for isolation, intensive care, and general hospital room), medication fee (medication / injection / anesthesia / whole blood and blood product), treatment and surgery fee, medical examination fee (inspection / medical imaging / computed tomography / magnetic resonance imaging / positron emission tomography / ultrasonography), therapeutic materials, and other factors (prosthetics, orthodontics / rehabilitation and physiotherapy / psychotherapy).

The family caregiver transportation fare in relation to hospitalization was estimated by multiplying referenced costs (2017 Korea Health Panel Study [20] and the 2017 Consumer Price Index [21]) by patient individual LOS. The term “family caregiver transportation costs” referred to the mean expenses for round-trip transportation for each visit of a family caregiver to a medical facility during the patient’s hospitalization [20]. The paid care cost was calculated by multiplying referenced average costs [22] by patient individual LOS. During the day, hospitalists administer care to patients in the hospitalist care

group while residents provide care under the direction of a subspecialist. During the night, residents care for patients in both groups. The daytime doctor labor costs were estimated and analyzed separately for residents, subspecialists, and hospitalists (Supplementary 2 and 4). Resident doctor labor costs per patient were estimated using the following variables: the average after-tax salary (2017 resident training environment evaluation survey results [23]), four major social insurance scheme classifications (national pension, health insurance, employment insurance, and workers' compensation insurance [24]) and tax (income tax and resident tax [25]), the number of inpatients per physician [26], and the total patient days (The total number of days for all inpatients) in the non-hospitalist care group. Subspecialist labor costs were calculated using a referenced average labor cost [27], the number of inpatients per physician [28, 29], and the total patient days in the non-hospitalist care group.

The AMU hospitalist labor costs per patient were calculated using a referenced average labor cost [30], number of AMU hospitalists, and AMU-LOS in the hospitalist care group. In addition, doctor labor costs for night shifts were estimated by reflecting the number of patients under the charge of residents [31], residents' average wage, and total patient days in the non-hospitalist care group.

Indirect costs

Indirect costs (time costs) were calculated by applying the gross-costing method. Patient productivity loss during hospitalization (time costs) was calculated by multiplying the average daily wage by gender and age [32], by individual LOS, and by the labor force participation rate [33]. Family caregiver productivity loss was calculated by multiplying the average daily wage of all workers [32] by individual LOS. Patient productivity loss due to ED-LOS was calculated by multiplying the average hourly wage by gender and age [32], by individual ED-LOS, and by the labor force participation rate [33]. Patient productivity loss due to death in hospitalization was calculated by multiplying the average annual wage by gender and age [32], by the labor force participation rate [33], and by individual life years gained in relation to death [34]. Individual life years gained were estimated by subtracting life expectancy reduced by major diseases from life expectancy by gender and age, in reference to life tables available from the

Korean Statistical Information Service (KOSIS, 2017) [34].

Benefit measure

In this study, the human capital approach was used as a method of evaluating the value of "health" or "life" in monetary units [17]. Benefits, in the form of cost savings, were then estimated based on direct and indirect costs.

Economic evaluation: benefit-cost analysis

In benefit-cost analysis, the BCR and net-benefit are used as indicators for decision indices. Net-benefit refers to benefit minus the cost, with a larger net-benefit indicating a more favorable benefit-cost situation [17]. Therefore, we used BCR and net-benefit as indicators in terms of decision indices.

Sensitivity analysis

This study is a retrospective study of costs incurred. As the study period comprised only one year, a discount rate was not applied to the costs and a sensitivity analysis was performed on uncertain variables [35]. The results of the sensitivity analysis are presented in a tornado diagram (Figure 1).

First, a sensitivity analysis was conducted on LOS and ED-LOS, which showed a skewed distribution. We analyzed the 1%-trimmed mean by calculating the average of the remaining values while excluding some (1%) from the extremes of the data.

Second, a sensitivity analysis was conducted on paid care costs among the direct non-medical costs that were considered to have high uncertainty. Assuming that no caregiver was hired, the baseline paid care costs were set at $53 [22], and the maximum daily paid care costs for hospitalized patients were set at $122 [22].

Third, a sensitivity analysis was conducted on doctor labor costs among the direct non-medical costs that were considered to have high uncertainty, with both one-way and two-way sensitivity analyses

conducted. Resident labor costs were set at $44,180 as a baseline, with a minimum value of $37,350 and a maximum value of $52,669 [23]. Hospitalist and specialist labor costs were set at $115,452 as a baseline [27, 30], with a minimum value of $76,458 and a maximum value of $152,917.

Statistical analysis

Categorical variables are reported as percentages, and continuous variables as mean ± standard deviation (SD). Groups were compared using Pearson's chi-square tests or t-tests, as appropriate. ACCI, LOS, and ED-LOS were expressed as the median and interquartile range (IQR). For these variables, groups were compared using the Mann-Whitney *U* test, owing to their skewed distributions. We performed subgroup analyses of costs and benefits according to age, severity of the patient's condition (based on the KTAS score), the degree of comorbidity (based on the ACCI score), and the major disease category (based on the ICD-10). Natural log-transformed multivariable regression analysis was conducted in relation to the costs. As the unit cost was large, using a natural logarithm can increase normality and enable accurate values to be obtained during analysis as well as reduce skewness and kurtosis of the data. Regression analysis for the costs was used to adjust for the following factors: age, sex, prior hospitalization, referral to specialty, consultation, CPR, KTAS score, ACCI score, surgical intervention, major disease, ICU admission, IHM, LOS, and ED-LOS. Using the estimates from the regression models, we presented differences between AMU hospitalized and non-hospitalized groups in terms of medical, direct, indirect, and total costs.

Patient and public involvement

This was a non-interventional study conducted retrospectively. Consequently, no patients participated directly in the study's conception, formulation of research objectives and queries, or execution. In addition, patients were not involved in the interpretation of results or production of the manuscript. It is not currently in our intentions to disseminate the findings to the study participants.

RESULTS

Costs

All costs are presented as costs per patient admission in this study. The estimated costs (US $1 = 1307.9 KRW, year: 2023 [36]) between the hospitalist group and the non-hospitalist group are shown in Table 2. The total costs were significantly lower in the hospitalist group than in the non-hospitalist group, with a difference of more than $6000 (20570±91024 *vs.* 27416±102360, *P*=0.007). The direct medical costs were significantly lower in the hospitalist group than in the non-hospitalist group, with a difference of more than $900 (4075±6504 *vs*. 5050±7255, *P*= 0.000).

Among the subcategories of medical costs, the biggest difference was found in relation to the admission fee and medical examination fee (886±1661 *vs.* 1167±1697, *P*=0.003; 1269±1629 *vs.* 1565±1676, *P*=0.000; respectively). Among the direct non-medical costs, the family caregiver transportation fare, paid care costs, and doctor labor costs were significantly lower in the hospitalist group than in the non-hospitalist group (*P*=0.007, *P*=0.007, and *P*=0.000; respectively).

The indirect costs were significantly lower in the hospitalist group than in the non-hospitalist group, with a difference of more than $5000 (14988±89375 *vs.* 20719±100689, *P*=0.021). Among the indirect costs, family caregiver productivity loss according to LOS and patient productivity loss according to ED-LOS and IHM were significantly lower in the hospitalist group than in the non-hospitalist group (*P*=0.007, *P*=0.000, and *P*=0.023, respectively). However, there were no significant differences between the two groups in terms of patient productivity loss according to LOS (560±782 *vs.* 549±788, *P*=0.570).

Table 2. Costs of patients cared for by hospitalists and non-hospitalists (N=6391)

Cost per patient admission (USD)	HG (n=2426)	NHG (n=3965)	*P* value
Total costs	20570±91024	27416±102360	0.007
Direct costs	5582±8003	6697±8729	0.000
Direct medical costs	4075±6504	5050±7255	0.000
Consultation fee	251±221	269±238	0.003
Admission fee	886±1661	1167±1697	0.000
Medication fee	907±2345	889±2324	0.774
Treatment and surgery fee	266±1092	432±1720	0.000
Medical examination fee	1269±1629	1565±1676	0.000
Therapeutic materials	304±866	552±1477	0.000
Others	191±596	176±467	0.249
Direct non-medical costs	1508±1688	1647±1786	0.002
Family caregiver transportation fare in hospitalization	198±219	213±231	0.007
Paid care cost in hospitalization	556±614	600±650	0.007
Doctor's labor cost	754±855	834±904	0.000
Indirect costs	14988±89375	20719±100689	0.021
Patient productivity loss according to LOS	560±782	549±788	0.570
Family caregiver productivity loss according to LOS	1124±1243	1213±1316	0.007
Patient productivity loss according to ED-LOS	76±75	86±90	0.000
Patient productivity loss according to IHM	13228±88992	18871±100401	0.023

Data are presented as mean ± standard deviation. HG, hospitalist group; NHG, non-hospitalist group; ED-LOS, emergency department-length of stay; LOS, length of hospital stay; IHM, in-hospital mortality; Cost unit: USD (US Dollar), ($1 = 1307.9 KRW, year: 2023)

Subgroup cost differences according to KTAS scores, comorbidity severity, major disease, and age

Cost analysis was performed according to subgroups of patients stratified by KTAS scores, ACCI scores, major disease, and age to determine differences between the two groups (Supplementary 5, 6, 7, and 8). Compared to the non-hospitalist group, the hospitalist group's overall costs for more urgent cases were significantly reduced by more than $8000 (*P*=0.002). In low-to-moderate comorbidity groups (ACCI = 0–2, 3, and 4 points), there was a greater cost reduction in the hospitalist group than in the non-hospitalist group ($12941, *P*=0.033; $10017, *P*=0.152; $8199, *P*=0.016; respectively).

Among the major diseases, in all but three disease types, the overall costs in relation to the hospitalist group decreased compared to the non-hospitalist group (Supplementary 7). In a subgroup analysis by age, total costs in the hospitalist group decreased in almost all age groups (*P*=0.248, *P*=0.004, *P*=0.000, *P*=0.002, *P*=0.001, respectively).

Natural log-transformed multivariable regression analysis of costs

We performed natural log-transformed multivariable regression analysis to adjust for clinical variables and outcome variables potentially associated with costs, namely, medical, direct, indirect, and total costs (Supplementary 9 and 10). Regression analysis revealed a significant 30% reduction in medical costs and a 29.3% reduction in total costs in the hospitalist group compared to the non-hospitalist group ($e^{-0.355}$=0.701, *P*=0.000; $e^{-0.346}$=0.707, *P*=0.000; respectively). Furthermore, there was a significant reduction of 28.6% in direct costs and a 23.3% reduction in indirect costs in the hospitalist group compared to the non-hospitalist group (**(**$e^{-0.336}$=0.714, *P*=0.000; $e^{-0.265}$=0.767, *P*= 0.000; respectively).

Benefit-cost analysis

Net-benefit and BCR analysis were conducted according to total and subgroups of patients stratified by clinical variables, KTAS scores, ACCI scores, major diagnoses, and age (Table 3). Among the total

group of patients, the net-benefit and BCR of the AMU hospitalist care group were $6846 and 1.33 per patient admission, respectively; overall net-benefit of AMU hospitalist care was found to be largely positive. Among the patients stratified by clinical variables, net-benefit and BCR of AMU hospitalist care was found to be largely positive in all but five 5 subgroups (less urgent; ACCI ≥5; diseases of the circulatory system; diseases of the genitourinary system; and endocrine, nutritional, and metabolic diseases).

Table 3. Benefit-cost analysis

Total Cost per patient admission (USD)	HG (A)	NHG (B)	Net-benefit (B-A)	B/A ratio (benefit cost ratio, BCR)
Total (N=6391)	20570	27416	6846	1.33
KTAS				
More urgency (n=5556)	20334	29074	8740	1.43
Less urgency (n=835)	21801	14269	-7532	0.65
ACCI				
ACCI ≤2 (n=1747)	16700	29640	12941	1.77
ACCI=3 (n=1169)	24948	34965	10017	1.40
ACCI=4 (n=1445)	14346	22545	8199	1.57
ACCI≥5 (n=2030)	25890	24894	-996	0.96
Major disease				
Malignant neoplasms (n=1735)	37059	63186	26127	1.71
Diseases of the circulatory system (n=600)	21568	10963	-10604	0.51
Diseases of the respiratory system (n=1141)	12369	18568	6199	1.50
Diseases of the digestive system (n=865)	10408	19732	9324	1.90
Diseases of the genitourinary system (n=577)	14018	11979	-2039	0.85
Symptoms, signs, and abnormal clinical and laboratory findings (n=329)	6724	10762	4038	1.60
Certain infectious and parasitic diseases (n=290)	5411	22358	16947	4.13
Endocrine, nutritional, and metabolic diseases (n=253)	13906	5765	-8142	0.41
Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism (n=177)	12512	65460	52948	5.23
Diseases of the musculoskeletal system and connective tissue (n=147)	9269	19916	10647	2.15
Others (n=277)	19377	28223	8846	1.46
Age (years)				
<50 (n=1098)	34234	46473	12238	1.36
50–59 (n=900)	36276	66967	30691	1.85
60–69 (n=1275)	14345	22699	8354	1.58
70–79 (n=1763)	11861	15868	4007	1.34
≥80 (n=1355)	9310	12453	3143	1.34

Data are presented as mean. HG, hospitalist group; NHG, non-hospitalist group; KTAS, Korean Triage and Acuity Scale; ACCI, Age-adjusted Charlson Comorbidity Index; Cost unit: USD (US Dollar), ($1 = 1307.9 KRW, year: 2023)

Sensitivity analysis

The sensitivity analysis results for LOS and ED-LOS are shown in Figures 1-1 and 1-2. We analyzed the 1%-trimmed mean and excluded patients with extreme values, as noted. After excluding extreme values related to LOS, the results were stable (net-benefit: $7162 to $8067, BCR: 1.31 to 1.33) and showed no significant difference from the baseline analysis. Sensitivity analysis for ED-LOS revealed that the results were similar to (net-benefit: $6311 to $6846, BCR: 1.31 to 1.33) the baseline analysis. After varying paid care costs from $0 to $122, the sensitivity analysis results were stable, with the net-benefit ranging from $8013 to $8138 and the BCR from 1.32 to 1.34 (Figure 1-3). One-way sensitivity analysis results showed comparative values of resident, specialist, and hospitalist labor costs (Supplementary 11,12, and 13), with resident labor costs ranging from $37,350 to $52,669, which indicated a net-benefit ranging from $6841 to $6851 (BCR, 1.33) (Supplementary 11). After varying specialist labor costs from $76,458 to $152,917, the results were similar to baseline estimates, with net-benefit ranging from $6764 to $6924 (BCR, 1.33) (Supplementary 12).

After varying hospitalist labor costs from $76,458 to $152,917, the results were stable, with net-benefit ranging from $6784 to $6910 (BCR, 1.33) (Supplementary 13).

Two-way sensitivity analysis results on hospitalist and resident labor costs showed that net-benefit ranged from $6779 to $6916 and BCR from 1.33 to 1.34 (Supplementary 14). Moreover, Two-way sensitivity analysis results on hospitalist and specialist labor costs showed that net-benefit ranged from $6703 to $6988 and BCR from 1.33 to 1.34 (Supplementary 15).

DISCUSSION

Study summary

This study is the first to report on the economic efficiency of a Korean AMU hospitalist care model while controlling for clinical factors. We found a notable cost reduction with AMU hospitalist care compared to non-hospitalist care in all areas: medical costs, direct costs, indirect costs, and total costs. In this study, medical costs included hospitalist care fees. The same trend toward cost reduction was

observed in the subgroup and regression analyses. In this study, the cost of doctor labor was estimated separately for each hospitalization flow and day and night shifts (Supplementary 4).

The net-benefit and BCR analysis results of the AMU hospitalist care group were $6846 and 1.33 per patient admission, respectively; overall, net-benefit of AMU hospitalist care was found to be largely positive. Sensitivity analysis showed that the net-benefit and BCR results of AMU hospitalist care were similar to baseline analysis.

In the present resident training system, which lacks a structured curriculum, training has taken the form of encountering more patients and accumulating experience over time. Many institutions still use the apprenticeship model of training to become specialists. The Medical Resident Act has been enacted to address this issue; however, the situation remains ambiguous in the field [37]. Moreover, residents who rotate annually or monthly will inevitably experience strained relationships with other professional teams, and medical treatment is frequently interrupted due to complications such as doctor-nurse disputes [2]. However, direct, real-time communication among our multidisciplinary team members, which enables appropriate and quick decision-making on treatments for patients with acute diseases, is a key component of our AMU care [3].

Further, consultation, formulation, and implementation of treatment plans and the treatment itself are responsibilities shared among residents, fellows, and attending specialists in the context of resident/attending specialist care. However, hospitalists carry the sole responsibility for all these tasks [38]. Moreover, hospitalists have extensive knowledge and proficiency in managing patients who are hospitalized. Their level of professionalism is unparalleled compared to that of residents with 1–2 years of experience, as evidenced by their critical thinking skills, patient communication capabilities, and accountability for treatment [38]. Consequently, these characteristics are believed to help reduce overall costs, including medical cost.

Furthermore, our previous study reported that AMU hospitalist care improved patient outcomes in terms of IHM, ICU admission rate, LOS, and ED-LOS [9]. This enhanced performance may have led to a reduction in indirect expenses and productivity loss.

Direct medical costs

Some previous studies that investigated the costs of hospitalist care have reported reduced medical costs in hospitalist care [10, 39-46]. In contrast, other studies have reported no significant difference in total medical costs between patients treated by hospitalists and those treated by non-hospitalists [7, 47] and that the costs of care for hospitalists were more than those for specialists but less than those for generalists [48]. Our study showed that there was a marked cost reduction in consultation, admission, treatment and surgery, medical examination, and therapeutic materials fees among the medical cost subcategories. Even when hospitalist care fees were included in medical costs, the hospitalist group's medical costs were lower, which indicates that the difference would be even greater if hospitalist care fees were excluded. Among the previous studies, one study that evaluated Korean hospitalists reported that medical costs reduced by $208 in terms of hospitalist care [10]. However, in our study, medical expenses per admission decreased by nearly $1000 in the hospitalist care group. The findings of research on medical cost reduction are consistent, but our study's findings on cost-reduction suggest a more substantial reduction is involved.

The patient group in our study consisted of patients with acute medical conditions admitted through the ED of a tertiary general hospital, with their disease severity being higher than that among those in the total group of patients, which may explain the difference in study results. However, the regression analyses showed a significant 30% reduction in medical costs in the hospitalist group after adjusting for clinical factors. Despite the conflicting results reported in earlier studies, our research findings offer compelling evidence supporting the effectiveness of the AMU hospitalist care model in reducing medical costs.

Direct non-medical costs compared with indirect costs

Studies are lacking on the economic implications of hospitalist care from a societal perspective. Hence, we conducted an estimation and analysis of non-medical expenses to assess the economic feasibility of AMU hospitalist care from a societal perspective.

In a previous study, we reported that AMU hospitalist care considerably improved patient outcomes in terms of IHM, ICU admission rate, LOS, and ED-LOS [9]. In this study, we used patient outcomes from that study to estimate the following costs: family caregiver transportation fares in hospitalization, paid care costs in hospitalization, patient productivity loss based on LOS, family caregiver productivity loss based on LOS, patient productivity loss based on ED-LOS, and patient productivity loss based on IHM.

The hospitalist care group's decreased LOS resulted in a notable reduction in expenses related to family caregiver transportation and paid care during patient hospitalization.

With the exception of patient productivity loss based on LOS, substantial reductions in expenses were shown for family caregiver productivity loss based on LOS and patient productivity loss based on ED-LOS and IHM. The hospitalist group exhibited a considerably reduced LOS in comparison to the non-hospitalist group [9]. However, it is possible that the lower age of the patients in the hospitalist group may account for the larger patient productivity loss based on LOS observed in this group. Nevertheless, AMU hospitalist care resulted in notable reductions in the indirect costs, surpassing $7000 in savings when compared to the non-hospitalist group. This improvement in patient outcomes played a pivotal role in achieving these cost reductions. Therefore, the overall costs in relation to the AMU hospitalist care group showed a notable decrease in comparison to the non-hospitalist group.

Benefit-cost analysis

The net-benefit and BCR analysis of the AMU hospitalist care group yielded results of $6846 and 1.33 per patient admission, respectively, indicating that the overall net-benefit of AMU hospitalist care was found to be largely positive. However, variations in net-benefit and BCR analysis ranges were seen across different subgroups (-$10604 to $52948, 0.41 to 5.23; respectively). This indicates that the economic efficacy of AMU hospitalist care varies based on the clinical characteristics of patients. Nevertheless, in terms of net-benefit and BCR results, the overall net-benefit of AMU hospitalist care was found to be largely positive in 17 subgroups and negative in five subgroups (less urgent; ACCI ≥5;

diseases of the circulatory system; diseases of the genitourinary system; and endocrine, nutritional, and metabolic diseases). It is possible that this population has a greater demand for specialized care; furthermore, treatment modalities and expenses can vary substantially based on the reason for admission even for the same disease. In our study, clinical variables were adjusted for factors such as age, severity, the major disease, and KTAS. To determine the precise reason for the negative results reported in these five groups, more research into the variables leading to hospitalization or disease-specific clinical outcomes is required.

These findings might potentially serve as a valuable reference for the development of a more efficient hospitalist care paradigm in further research.

A one-way sensitivity analysis was conducted to examine the impact of variations in the LOS, ED-LOS, paid care costs, and doctor labor costs. The net-benefit and BCR analysis results of AMU hospitalist care were stable based on a one-way sensitivity analysis using these four variables. The results of a two-way sensitivity analysis indicated that the net-benefit and BCR results of AMU hospitalist care were similar to the baseline estimates despite fluctuations in labor costs for resident, specialist, and hospitalist.

Limitations

This study had some limitations. First, it employed a retrospective design, which posed challenges in mitigating the effect of confounding factors and discerning whether the observed results were attributable to the AMU environment or the treatment administered by the hospitalists. Second, the study was conducted at a single site, which limits the extent to which our findings may be generalized. Third, other expenditures, excluding medical expenses, were not directly obtained but rather calculated by consulting relevant sources, which introduced a degree of uncertainty into the cost estimations. Fourth, the present study could not provide a quantifiable assessment of the potential benefits associated with the reduction of ICU admissions. Five, the value and benefits of teaching services were not evaluated in this study. Even if costs are higher for teaching services compared to non-teaching services,

training future physicians is a valuable goal. Hence, further investigation to ascertain the value and benefits of teaching services from a societal perspective is required.

CONCLUSION

This study showed that AMU hospitalist care significantly reduced costs in nearly all categories, including medical costs, direct costs, indirect costs, and total costs. Moreover, in the benefit-cost analysis, the net-benefit and BCR results of the AMU hospitalist care group were shown to be greater than $6000 and 1.30 per patient admission, respectively. These results indicate that the overall net-benefit of AMU hospitalist care is largely positive. Nevertheless, further investigation is necessary to identify the factors that contribute to hospitalization or disease-specific clinical outcomes.

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Author Contributions

Conceptualization: Kim HJ, Kim JH, Ohn JH, Kim N-H. Methodology: Kim HJ, Kim JH, Ohn JH, Kim N-H. Software: Kim HJ. Validation: Kim HJ, Kim JH, Ohn JH, Kim N-H. Formal analysis: Kim HJ. Investigation: Kim HJ, Kim JH, Ohn JH, Kim N-H. Data curation: Kim HJ. Writing – original draft: Kim HJ. Writing - review & editing: Kim HJ, Kim JH, Ohn JH, Kim N-H. All authors have read and approved the final draft of the manuscript. JK is guarantor.

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Competing interests

The authors have no potential conflicts of interest to disclose.

Patient consent for publication

Not applicable.

Ethics approval

Ethical approval was provided by the Institutional Review Board of Seoul National University Bundang Hospital (IRB No. B-1711/435-107). Our institution's ethics committee waived the need for informed consent owing to the retrospective nature of the study and the use of anonymized data previously collected for routine clinical care.

Data availability statement

Data are available from the corresponding author upon reasonable request.

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Figures

Figure 1. One-way sensitivity analysis for the length of hospital stay, emergency department-length of stay, and paid care cost

Supplementary Materials

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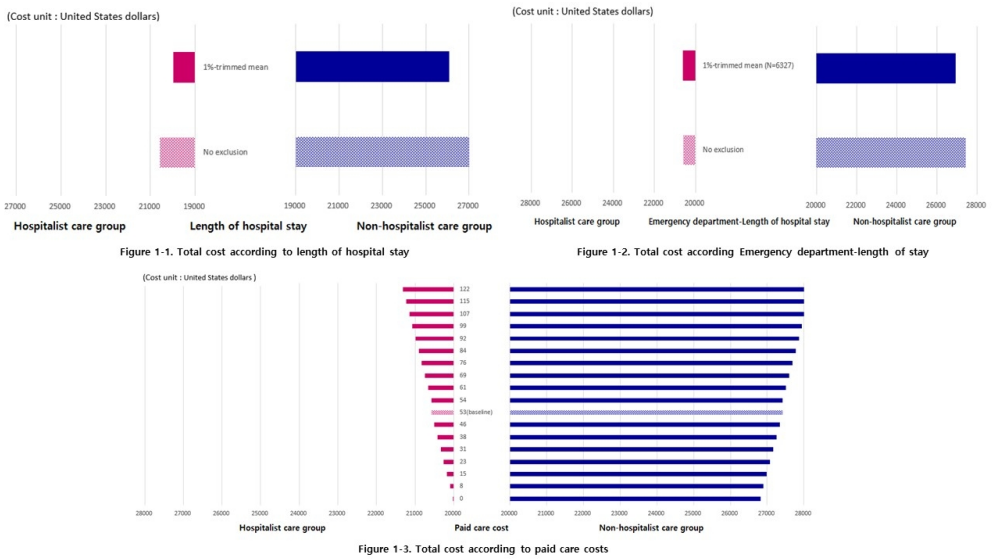

Figure 1. One-way sensitivity analysis for the length of hospital stay, emergency department-length of stay, and paid care cost

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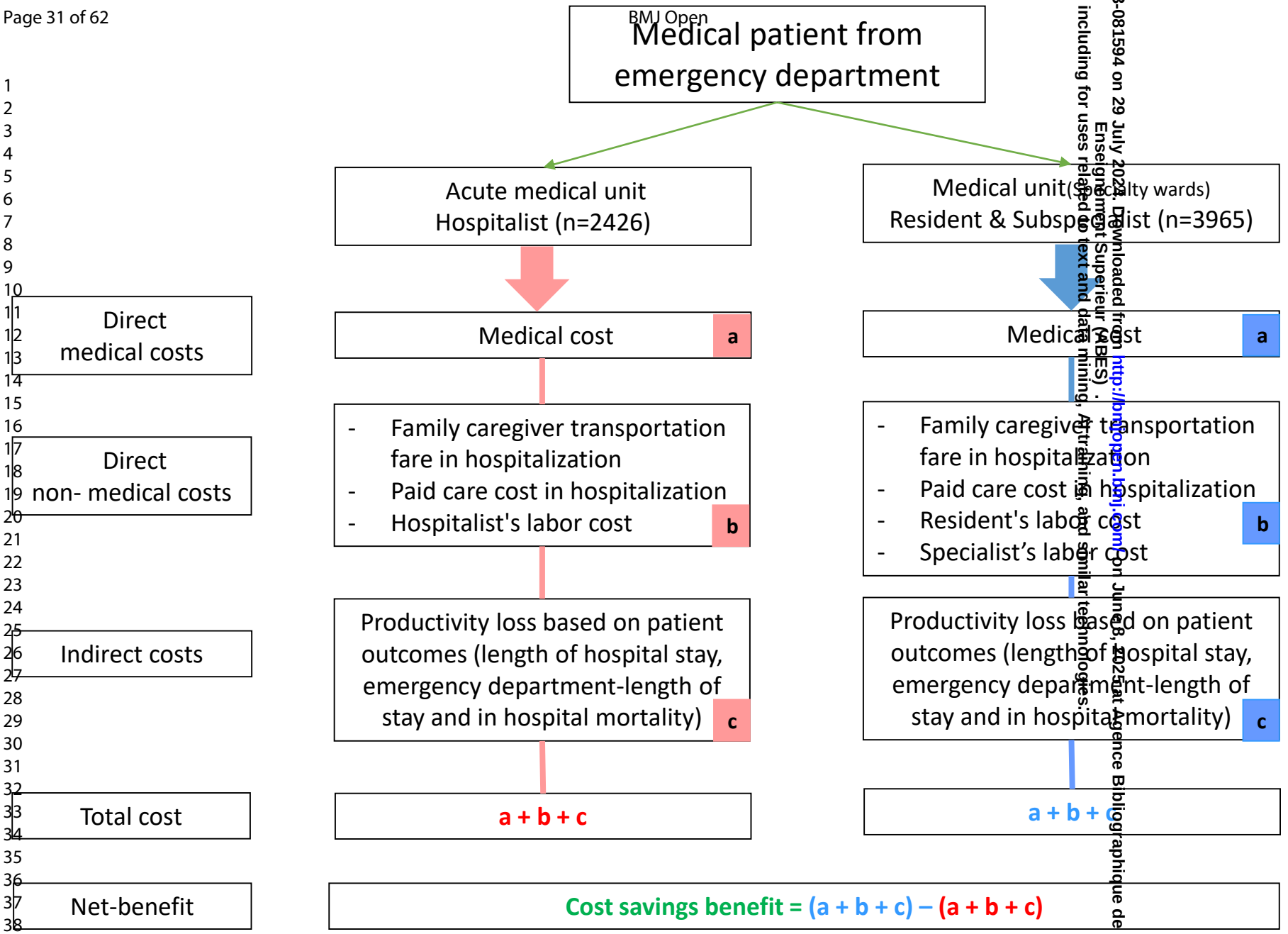


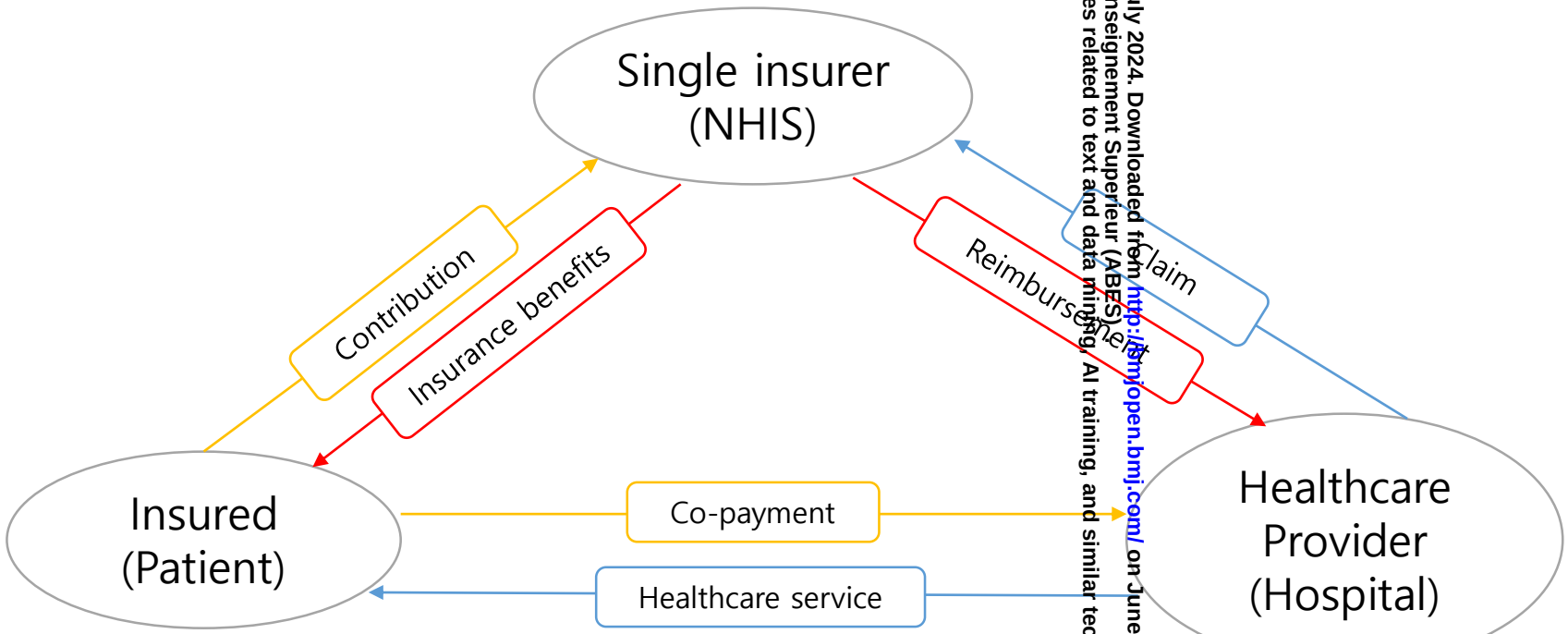
Supplementary 1. Flow diagram of the study population and benefit-cost factors

Supplementary 2. Type of costs, cost estimation formula and data source

Type of costs	Cost estimation formula & data source
Direct costs	C1 + C2 + C3 + C4
Direct medical costs	C1
Total medical expense in hospitalization (C1)	Individual medical treatment bill receipt (real data) ① consultation fee ② admission fee ③ medication fee (including medication / injection / anesthesia / WB and blood product) ④ treatment and surgery fee ⑤ medical examintaion fee (including inspection / medical imaging / CT / MRI /PET / Ultrasonography) ⑥ therapeutic materials ⑦ the others (prosthetics, orthodontics / rehab and physiotherapy / psycotherapy)
Direct non-medical costs	C2 + C3 + C4
Family caregiver transportation fare in hospitalization (C2)	$19* LOS 2017 Korea health panel study / 2019 Annual report on the consumer price index (referenced data), LOS : real data
Paid care cost in hospitalization (C3)	$53 * LOS The Social Cost of Informal Nursing Care and its Policy Implications for Integrated Nursing and Care Services (2021)(referenced data), LOS : real data
Doctor's labor cost (C4)	
Resident's labor costs (day shift)	2017 resident training environment evaluation survey results
Salary after tax	$26,760 ~ $35,935, average salary after tax : $30,851
Resident's labor costs per doctor	$37,350 ~ $52,669 Estimating using 4 Major SIS's (Social Insurance Schemes; national pension, health insurance, employment insurance, workers' compensation insurance) and tax (income tax and resident tax)
Resident's average labor costs per doctor	$44,180
Number of inpatient per day per doctor	17
Number of inpatients per year per doctor	17*365=6,205
Total number of resident assigned to the NHG group	Total patient days of NHG group (45,196) / Number of inpatients per year per doctor (6,205) =7.3
Total Resident's labor costs in the in the NHG group	$44,180 * 7.3 = $322,514
Resident's labor costs per patient per day in the NHG group	$322,514 / 45,196 = $7
Resident's labor costs per patient in the NHG group	$7 * LOS per admission
Resident's labor costs (night shift)	2017 resident training environment evaluation survey results
Number of inpatient per day per doctor	41.8
Number of inpatients per year per doctor	41.8*365=15,257
Total number of resident assigned to the NHG group	Total patient days of NHG group (45,196) / Number of inpatients per year per doctor (15,257) =2.96 (3)

Type of costs	Cost estimation formula & data source
Total Resident's labor costs in the in the NHG group	$44,180 * 3 = $132,540
Resident's labor costs per patient per day in the NHG group	$132,540 / 45,196 = $3
Resident's labor costs per patient in the NHG group	$3 * LOS per admission
Specialist's labor costs (day shift)	2017 Specialist salary evaluation survey results
Specialist's average labor costs per doctor	average $115,452
Number of average inpatient per day per doctor	5
Number of inpatients per year per doctor	5*365=1825
Total number of specialist assigned to the NHG group	Total patient days of the control group (45,196)/1825 =45196/1825=24.7
Total specialist's labor costs in the NHG group	$115,452 *24.7= $2,851,664
Specialist's labor costs per patient per day in the NHG group	$ 2,851,664/ 45196 (total patient days) = $63
Specialist's labor costs per patient in the NHG group	$63 * LOS per admission
Hospitalist's labor costs (day shift)	A study on the implementation and the evaluation of Korean hospitalist system to improve the quality of hospitalization (phase 2)(2018)
Hospitalist's labor costs per doctor	average $115452
Total number of hospitalist assigned to the HG group	4
Hospitalist's labor costs per patient per day of AMU in the HG group	$461,808 / 7216 (Total AMU-LOS) = $64
Doctor's labor cost per patient in the HG group	
1) No referral patients	($64 +$3)* AMU-LOS
2) Referral patients	($64 +$3)* AMU-LOS+ ($63+ $7 + $3)* referral medical ward-LOS
Indirect Costs	C5 + C6 + C7 + C8
Family caregiver productivity loss according to LOS (C5)	$106 * LOS 2017 Survey report on labor conditions by employment type (referenced data), LOS (real data)
Patient productivity loss according to ED-LOS (C6)	Hourly wage * ED-LOS * labor force participation rate (age, gender) 2017 Survey report on labor conditions by employment type (referenced data) 2017 Annual report on the the economically active population survey (referenced data), ED-LOS (real data)
Patient productivity loss according to LOS (C7)	Daily wage * LOS * labor force participation rate (age, gender) 2017 Survey report on labor conditions by employment type (referenced data) 2017 Annual report on the the economically active population survey (referenced data)
Patient productivity loss according to IHM (C8)	Annual wage * deceased patients' expected LYGs * labor force participation rate (age, gender) Statistics Korea. LIFE TABLES FOR KOREA, 2017 (referenced data) 2017 Survey report on labor conditions by employment type (referenced data) 2017 Annual report on the the economically active population survey (referenced data) In hospital mortality (real data)

HG, hospitalist group; NHG, non-hospitalist group; AMU, acute medical unit; LOS, length of hospital stay; ED, emergency department; Cost unit: USD ($1= 1307.9 KRW, year: 2023)



Supplementary 3. Governance of National Health Insurance in South Korea

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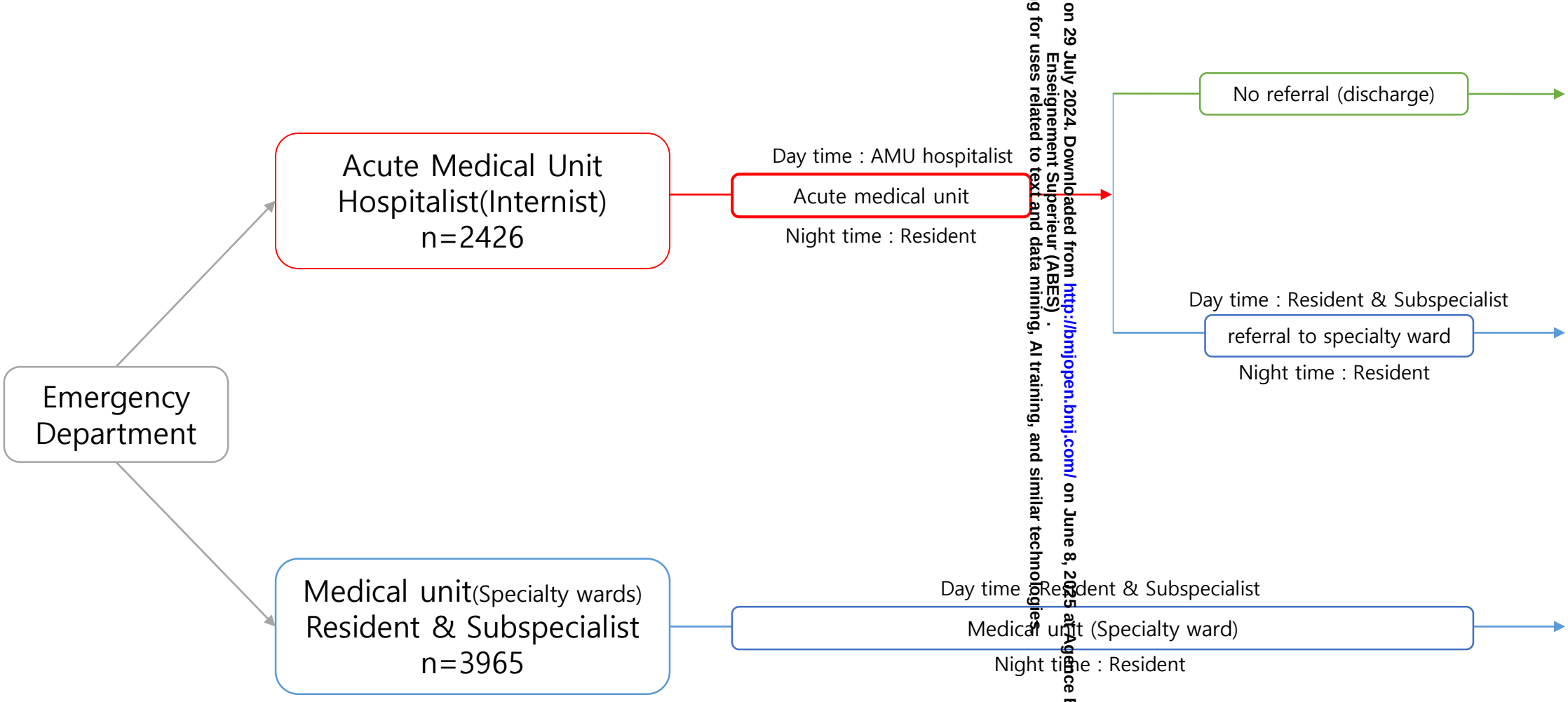


Supplementary 4. Doctor labor cost estimation by patients flow and timeline

Supplementary 5. Cost analysis for urgent and non-urgent cases treated by hospitalists or non-hospitalists (N=639)

	KTAS 1-3: More Urgent (N=5556)			KTAS 4-5: Less Urgent (N=835)		
Cost per patient admission (USD)	**HG (n=2035)**	**NHG (n=3521)**	***P* value**	**HG (n=391)**	**NHG (n=444)**	***P* value**
Total costs	20334±90283	29074±106747	0.002	21801±94897	14269±54923	0.155
Direct costs	5655±8094	6794±8918	0.000	5205±7510	5931±7013	0.150
Direct medical costs	4138±6531	5136±7428	0.000	3747±6363	4371±5666	0.135
Consultation fee	255±228	272±239	0.009	232±183	247±229	0.319
Admission fee	900±1754	1184±1726	0.000	813±1046	1031±1434	0.013
Medication fee	917±2027	901±2321	0.791	850±3570	796±2349	0.794
Treatment and surgery fee	273±1120	454±1797	0.000	227±932	263±884	0.564
Medical examination fee	1288±1684	1585±1704	0.000	1172±1309	1402±1430	0.016
Therapeutic materials	310±896	563±1498	0.000	272±686	469±1292	0.007
Others	193±588	178±475	0.275	181±634	163±397	0.619
Direct non-medical costs	1517±1744	1658±1803	0.005	1458±1363	1560±1649	0.335
Family caregiver transportation fare in hospitalization	199±226	215±234	0.014	191±176	202±214	0.433
Paid care cost in hospitalization	559±634	604±656	0.014	538±496	568±600	0.433
Doctor's labor cost	759±883	840±913	0.001	729±691	790±835	0.255
Indirect costs	14679±88509	22280±105035	0.006	16595±93852	8338±53705	0.114
Patient productivity loss according to LOS	567±815	542±758	0.254	525±576	600±994	0.189
Family caregiver productivity loss according to LOS	1131±1284	1222±1328	0.014	1088±1003	1149±1215	0.433
Patient productivity loss according to ED-LOS	77±75	86±91	0.000	72±73	86±87	0.015
Patient productivity loss according to IHM	12904±88065	20430±104737	0.006	14910±93772	6503±53499	0.107

Data are presented as mean ± standard deviation. HG, hospitalist group; NHG, non-hospitalist group; ED-LOS, emergency department length of stay; LOS, length of hospital stay; IHM, in hospital mortality; KTAS, Korean Triage and Acuity Scale; Cost unit: USD (U.S. Dollar), ($1=1307.9 KRW, year: 2023)

Supplementary 6. Cost analysis for patients with different comorbidity severities treated by hospitalists or non-hospitalists (N=6391)

	ACCI: 0-2 (N=1747)			ACCI: 3 (N=1169)		
Cost per patient admission (USD)	**HG (n=729)**	**NHG (n=1018)**	***P* value**	**HG (n=436)**	**NHG (n=733)**	***P* value**
Total costs	16700±97346	29640±141104	0.033	24948±111135	34965±117962	0.152
Direct costs	4079±5180	5430±8851	0.000	4945±6561	6614±8410	0.000
Direct medical costs	2955±4186	4130±7616	0.000	3545±5099	5006±6938	0.000
Consultation fee	207±163	225±216	0.065	227±162	259±218	0.007
Admission fee	612±794	852±1301	0.000	806±1855	1191±1860	0.001
Medication fee	669±1650	792±2939	0.308	822±2196	868±1975	0.712
Treatment and surgery fee	188±713	350±2163	0.053	191±481	457±1543	0.000
Medical examination fee	968±1143	1312±1586	0.000	1107±1243	1559±1672	0.000
Therapeutic materials	226±613	495±1361	0.000	231±442	512±1170	0.000
Others	85±150	105±198	0.023	163±460	160±395	0.905
Direct non-medical costs	1123±1134	1300±1506	0.008	1399±1568	1608±1749	0.041
Family caregiver transportation fare in hospitalization	148±147	168±195	0.017	184±203	208±227	0.065
Paid care cost in hospitalization	416±412	473±548	0.017	517±571	585±637	0.065
Doctor's labor cost	559±575	658±763	0.003	699±794	814±885	0.026
Indirect costs	12621±96482	24210±139010	0.052	20003±109606	28351±116657	0.227
Patient productivity loss according to LOS	590±683	686±1006	0.026	601±814	585±864	0.749
Family caregiver productivity loss according to LOS	842±835	958±1110	0.017	1046±1155	1184±1288	0.065
Patient productivity loss according to ED-LOS	96±86	120±108	0.000	77±71	92±108	0.011
Patient productivity loss according to IHM	11093±96269	22446±138553	0.057	18280±109064	26491±116420	0.233

Supplementary 5. Cost analysis for patients with different comorbidity severities treated by hospitalists or non-hospitalists (N=6391)

	ACCI: 4 (N=1445)			ACCI: ≥5 (N=2030)		
Cost per patient admission (USD)	**HG (n=502)**	**NHG (n=943)**	***P* value**	**HG (n=759)**	**NHG (n=1271)**	***P* value**
Total costs	14346±46751	22545±67961	0.016	25890±93774	24894±72473	0.789
Direct costs	5315±6670	6754±7792	0.000	7569±10891	7718±9325	0.745
Direct medical costs	3833±5553	5079±6432	0.000	5614±8912	5791±7629	0.635
Consultation fee	247±165	270±202	0.025	311±304	310±279	0.939
Admission fee	879±1158	1222±1657	0.000	1200±2277	1364±1865	0.078
Medication fee	926±3272	874±2016	0.709	1171±2236	991±2157	0.073
Treatment and surgery fee	168±372	398±1248	0.000	448±1747	509±1718	0.437
Medical examination fee	1224±1311	1603±1637	0.000	1682±2223	1742±1753	0.504
Therapeutic materials	250±583	561±1586	0.000	458±1290	615±1632	0.024
Others	138±279	151±310	0.428	345±951	260±690	0.021
Direct non-medical costs	1482±1320	1675±1606	0.021	1956±2229	1927±2071	0.771
Family caregiver transportation fare in hospitalization	195±171	217±208	0.038	256±289	250±268	0.643
Paid care cost in hospitalization	546±480	610±585	0.038	718±811	702±754	0.643
Doctor's labor cost	741±668	848±813	0.012	982±1129	976±1049	0.902
Indirect costs	9031±44942	15791±65530	0.039	18321±91272	17176±71183	0.753
Patient productivity loss according to LOS	418±605	413±467	0.863	602±932	518±711	0.023
Family caregiver productivity loss according to LOS	1106±972	1234±1183	0.038	1453±1642	1420±1526	0.643
Patient productivity loss according to ED-LOS	54±50	63±63	0.010	70±74	72±70	0.643
Patient productivity loss according to IHM	7452±44743	14081±65244	0.042	16195±90754	15167±71041	0.776

Data are presented as mean ± standard deviation. HG, hospitalist group; NHG, non-hospitalist group; ED-LOS, emergency department length of stay; LOS,

length of hospital stay; IHM, in hospital mortality; ACCI, Age-adjusted Charlson Comorbidity Index; Cost unit: USD (U.S. Dollar), ($1=1307.9 KRW, year: 2023)

Supplementary 7. Cost analysis according to major diseases between hospitalist and non-hospitalist groups (N=6391)

	Malignant neoplasms (N=1735)			Diseases of the circulatory system (N=600)		
Cost per patient admission (USD)	**HG (n=845)**	**NHG (n=890)**	***P* value**	**HG (n=48)**	**NHG (n=552)**	***P* value**
Total costs	37059±128241	63186±163463	0.000	21568±84888	10963±37071	0.100
Direct costs	6745±7389	8040±8268	0.001	5861±6678	6706±10303	0.577
Direct medical costs	4971±6044	6076±6910	0.000	4475±5856	5511±9028	0.435
Consultation fee	279±208	307±220	0.007	233±140	210±200	0.438
Admission fee	1066±1330	1355±1482	0.000	801±838	865±1514	0.772
Medication fee	1288±2927	1582±2985	0.039	805±1995	415±1808	0.156
Treatment and surgery fee	231±566	374±1261	0.003	382±1522	532±2658	0.700
Medical examination fee	1437±1524	1704±1524	0.001	1431±1314	1700±1771	0.303
Therapeutic materials	369±767	443±773	0.045	690±2848	1672±3114	0.035
Others	300±846	311±816	0.780	134±190	117±308	0.710
Direct non-medical costs	1774±1573	1964±1690	0.007	1386±1089	1195±1550	0.404
Family caregiver transportation fare in hospitalization	232±204	255±219	0.028	182±141	155±201	0.357
Paid care cost in hospitalization	652±573	715±615	0.028	512±397	435±564	0.357
Doctor's labor cost	890±796	995±856	0.009	692±550	605±785	0.453
Indirect costs	30314±126770	55146±163122	0.000	15706±84189	4257±35265	0.066
Patient productivity loss according to LOS	703±873	721±834	0.674	531±683	359±651	0.082
Family caregiver productivity loss according to LOS	1320±1159	1447±1245	0.028	1036±804	881±1142	0.357
Patient productivity loss according to ED-LOS	84±85	109±121	0.000	74±60	64±63	0.283
Patient productivity loss according to IHM	28206±126390	52868±163024	0.000	14065±84010	2953±35224	0.074

Supplementary 5. Costs analysis according to major diseases between hospitalist and non-hospitalist groups (N=6291)

	Diseases of the respiratory system (N=1141)			Diseases of the digestive system (N=865)		
Cost per patient admission (USD)	**HG (n=266)**	**NHG (n=875)**	***P* value**	**HG (n=441)**	**NHG (n=424)**	***P* value**
Total costs	12369±28381	18568±58264	0.904	10408±66247	19732±94288	0.092
Direct costs	6392±14038	6756±7626	0.585	3994±5522	5143±6628	0.006
Direct medical costs	4622±11505	4896±6064	0.610	2942±4606	3932±5768	0.005
Consultation fee	274±324	280±211	0.713	210±151	229±166	0.072
Admission fee	1257±3766	1444±1942	0.283	560±807	781±1151	0.001
Medication fee	649±1527	655±1082	0.947	546±1361	717±1612	0.092
Treatment and surgery fee	477±2303	480±1181	0.982	296±1022	412±1469	0.176
Medical examination fee	1508±2834	1548±1650	0.773	947±1200	1250±1407	0.001
Therapeutic materials	275±1149	321±864	0.486	302±596	465±1079	0.006
Others	182±495	169±324	0.609	82±303	79±131	0.866
Direct non-medical costs	1770±2731	1860±1779	0.529	1052±1103	1211±1102	0.035
Family caregiver transportation fare in hospitalization	232±354	241±231	0.617	139±143	157±143	0.060
Paid care cost in hospitalization	651±994	677±648	0.617	389±401	441±401	0.060
Doctor's labor cost	887±1384	942±901	0.450	524±559	613±558	0.020
Indirect costs	5977±21125	11812±56671	0.100	6414±63518	14589±92439	0.129
Patient productivity loss according to LOS	495±617	539±589	0.292	438±600	425±475	0.728
Family caregiver productivity loss according to LOS	1318±2011	13705±1311	0.617	788±812	892±812	0.060
Patient productivity loss according to ED-LOS	61±55	67±61	0.176	78±75	109±102	0.000
Patient productivity loss according to IHM	4103±20697	9835±56509	0.105	5110±62720	13163±92261	0.132

Supplementary 5. Costs analysis according to major diseases between hospitalist and non-hospitalist groups (N=6391)

	Diseases of the genitourinary system (N=577)			Symptoms, signs and abnormal clinical and laboratory findings (N=329)		
Cost per patient admission (USD)	**HG (n=202)**	**NHG (n=375)**	***P* value**	**HG (n=162)**	**NHG (n=167)**	***P* value**
Total costs	14018±80863	11979±59324	0.730	6724±9524	10762±50267	0.316
Direct costs	4586±6045	5240±5305	0.179	4513±4763	4322±4123	0.698
Direct medical costs	3232±4721	3819±4212	0.127	3324±3901	3358±3469	0.935
Consultation fee	240±216	265±194	0.159	215±147	188±113	0.061
Admission fee	709±1072	909±1247	0.054	667±1029	664±897	0.978
Medication fee	487±924	505±688	0.797	412±873	272±819	0.133
Treatment and surgery fee	251±867	398±962	0.069	191±843	144±561	0.555
Medical examination fee	1209±1429	1349±1163	0.206	1425±1115	1576±1247	0.249
Therapeutic materials	211±740	263±668	0.391	287±594	443±687	0.027
Others	124±341	129±216	0.833	127±364	69±88	0.049
Direct non-medical costs	1354±1393	1422±1218	0.548	1188±1020	965±828	0.029
Family caregiver transportation fare in hospitalization	178±180	184±158	0.679	157±132	125±107	0.017
Paid care cost in hospitalization	501±506	518±443	0.679	440±372	351±302	0.017
Doctor's labor cost	675±706	720±617	0.433	591±516	488±419	0.048
Indirect costs	9432±80267	6739±59151	0.647	2211±7619	6440±49512	0.283
Patient productivity loss according to LOS	390±433	398±401	0.827	432±518	315±339	0.015
Family caregiver productivity loss according to LOS	1013±1025	1048±898	0.679	891±753	711±610	0.017
Patient productivity loss according to ED-LOS	63±56	72±60	0.061	74±69	65±57	0.201
Patient productivity loss according to IHM	7967±80156	5221±59220	0.640	814±7629	5349±49507	0.250

Supplementary 5. Costs analysis according to major diseases between hospitalist and non-hospitalist groups (N=6391)

	Certain infectious and parasitic diseases (N=290)			Endocrine, nutritional and metabolic diseases (N=253)		
Cost per patient admission (USD)	**HG (n=86)**	**NHG (n=204)**	***P* value**	**HG (n=95)**	**NHG (n=158)**	***P* value**
Total costs	5411±4722	22358±91703	0.088	13906±78014	5765±8350	0.194
Direct costs	3883±3635	6816±10268	0.010	4368±7154	4229±6390	0.873
Direct medical costs	2568±2562	5124±8747	0.008	3049±5368	2940±4887	0.868
Consultation fee	215±154	269±267	0.081	247±298	220±190	0.382
Admission fee	692±782	1452±2060	0.001	643±877	772±1342	0.403
Medication fee	430±475	1010±3434	0.120	491±1521	334±739	0.272
Treatment and surgery fee	107±382	414±1780	0.116	278±1157	188±727	0.450
Medical examination fee	874±817	1562±1959	0.002	1052±1331	1154±1493	0.582
Therapeutic materials	132±378	297±706	0.042	201±719	148±388	0.451
Others	118±171	121±171	0.890	138±373	123±337	0.745
Direct non-medical costs	1315±1144	1693±1837	0.078	1320±1893	1289±1562	0.891
Family caregiver transportation fare in hospitalization	173±148	219±238	0.096	174±245	167±202	0.818
Paid care cost in hospitalization	486±416	616±669	0.096	488±688	469±569	0.818
Doctor's labor cost	655±580	857±930	0.063	658±959	653±791	0.963
Indirect costs	1529±1142	15542±85899	0.132	9538±77367	1536±2047	0.194
Patient productivity loss according to LOS	475±390	593±911	0.248	547±1405	495±927	0.722
Family caregiver productivity loss according to LOS	984±842	1247±1353	0.096	987±1393	950±1151	0.818
Patient productivity loss according to ED-LOS	69±59	98±101	0.014	70±67	91±93	0.061
Patient productivity loss according to IHM	0±0	13603±85029	0.139	7933±77324	0±0	0.198

Supplementary 5. Costs analysis according to major diseases between hospitalist and non-hospitalist groups (N=6391)

	Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism (N=177)			Diseases of the musculoskeletal system and connective tissue (N=147)		
Cost per patient admission (USD)	**HG (n=130)**	**NHG (n=47)**	***P* value**	**HG (n=58)**	**NHG (n=89)**	***P* value**
Total costs	12512±56607	65460±236052	0.018	9269±12785	19916±41366	0.059
Direct costs	5347±9271	11120±17718	0.006	6952±10169	9882±15156	0.198
Direct medical costs	4096±7591	8910±15066	0.006	4911±8119	6869±10992	0.246
Consultation fee	216±217	372±408	0.001	318±324	431±582	0.181
Admission fee	815±1308	1497±2129	0.011	1120±1601	1679±3139	0.212
Medication fee	1851±4590	4170±8980	0.026	795±1826	1126±2184	0.340
Treatment and surgery fee	101±385	351±1111	0.027	397±1677	678±2170	0.405
Medical examination fee	877±1456	2081±2924	0.000	1594±2083	2076±2464	0.221
Therapeutic materials	109±322	244±508	0.038	365±1187	555±1404	0.396
Others	126±245	195±323	0.136	322±983	325±575	0.982
Direct non-medical costs	1252±1771	2210±2811	0.008	2041±2220	3013±4370	0.119
Family caregiver transportation fare in hospitalization	165±229	286±364	0.009	267±288	390±566	0.128
Paid care cost in hospitalization	463±644	805±1023	0.009	751±808	1097±1591	0.128
Doctor's labor cost	624±898	1119±1423	0.007	1023±1125	1526±2213	0.112
Indirect costs	7164±54445	54339±225117	0.027	2317±2716	10034±30967	0.061
Patient productivity loss according to LOS	502±864	1085±1937	0.006	724±1176	973±1201	0.218
Family caregiver productivity loss according to LOS	937±1304	1629±2071	0.009	1520±1635	2220±3220	0.128
Patient productivity loss according to ED-LOS	76±62	79±69	0.760	73±72	95±97	0.149
Patient productivity loss according to IHM	5649±53865	51546±222629	0.030	0±0	6747±29316	0.082

Supplementary 5. Costs analysis according to major diseases between hospitalist and non-hospitalist groups (N=6291)

	Others (N=277)		
Cost per patient admission (USD)	**HG (n=93)**	**NHG (n=184)**	***P* value**
Total costs	19377±105815	28223±115873	0.537
Direct costs	6402±6756	7917±12833	0.288
Direct medical costs	4563±5134	5927±10870	0.253
Consultation fee	276±253	326±373	0.238
Admission fee	932±970	1402±2387	0.070
Medication fee	1323±2546	1207±2713	0.732
Treatment and surgery fee	217±673	700±3802	0.226
Medical examination fee	1297±1256	1695±2068	0.090
Therapeutic materials	346±985	419±1140	0.597
Others	172±287	178±302	0.869
Direct non-medical costs	1839±1890	1989±2429	0.601
Family caregiver transportation fare in hospitalization	241±245	258±315	0.646
Paid care cost in hospitalization	676±687	724±884	0.646
Doctor's labor cost	922±959	1007±1230	0.560
Indirect costs	12975±104723	20306±111437	0.598
Patient productivity loss according to LOS	702±847	787±1514	0.612
Family caregiver productivity loss according to LOS	1368±1390	1465±1790	0.646
Patient productivity loss according to ED-LOS	82±104	101±93	0.111
Patient productivity loss according to IHM	10824±104381	17952±110517	0.606

Data are presented as mean ± standard deviation. HG, hospitalist group; NHG, non-hospitalist group; ED-LOS, emergency department length of stay; LOS,

length of hospital stay; IHM, in hospital mortality; Cost unit: USD (U.S. Dollar), ($1=1307.9 KRW, year: 2023)

Supplementary 8. Cost analysis according to age between hospitalist and non-hospitalist groups (N=6391)

	Age < 50yrs (N=1098)			Age : 50-59yrs (N=900)		
Cost per patient admission (USD)	**HG (n=488)**	**NHG (n=610)**	***P* value**	**HG (n=401)**	**NHG (n=499)**	***P* value**
Total costs	34234±156382	46473±187530	0.248	36276±130259	66967±179600	0.004
Direct costs	4965±7242	5876±10166	0.096	5692±6952	7175±9271	0.008
Direct medical costs	3613±5814	4448±8728	0.070	4189±5572	5538±7717	0.003
Consultation fee	228±220	237±232	0.508	246±209	270±262	0.151
Admission fee	771±1372	972±1629	0.030	822±1027	1091±1540	0.003
Medication fee	900±1892	931±2958	0.840	1091±2590	1259±3331	0.407
Treatment and surgery fee	221±1037	402±2643	0.155	216±546	433±1481	0.006
Medical examination fee	1058±1452	1362±1855	0.003	1273±1478	1645±1761	0.001
Therapeutic materials	256±715	410±1298	0.019	314±688	636±1332	0.000
Others	179±619	134±293	0.118	227±706	204±621	0.611
Direct non-medical costs	1352±1593	1428±1674	0.450	1503±1534	1637±1924	0.256
Family caregiver transportation fare in hospitalization	178±206	185±217	0.573	197±199	212±249	0.327
Paid care cost in hospitalization	499±580	520±610	0.573	554±558	596±701	0.327
Doctor's labor cost	675±807	723±848	0.346	752±778	829±974	0.197
Indirect costs	29269±154339	40597±184984	0.279	30584±128853	59792±177975	0.006
Patient productivity loss according to LOS	828±1155	858±1165	0.673	974±1022	1057±1300	0.298
Family caregiver productivity loss according to LOS	1010±1173	1052±1234	0.573	1121±1130	1206±1418	0.327
Patient productivity loss according to ED-LOS	108±90	138±123	0.000	127±102	170±137	0.000
Patient productivity loss according to IHM	27322±153740	38550±184509	0.281	28362±128452	57359±177723	0.006

Supplementary 6. Cost analysis according to age between hospitalist and non-hospitalist groups (N=6391)

	Age : 60-69yrs (N=1275)			Age : 70-79yrs (N=1763)		
Cost per patient admission (USD)	**HG (n=542)**	**NHG (n=733)**	***P* value**	**HG (n=632)**	**NHG (n=1131)**	***P* value**
Total costs	14345±35835	22699±45307	0.000	11861±22867	15868±28322	0.002
Direct costs	5327±6734	7278±9428	0.000	6154±10486	6936±9155	0.103
Direct medical costs	3915±5716	5517±7852	0.000	4500±8559	5232±7548	0.063
Consultation fee	240±162	285±255	0.000	264±230	277±246	0.300
Admission fee	855±1166	1208±1712	0.000	1024±2555	1199±1843	0.098
Medication fee	930±3214	1132±2876	0.239	902±2019	818±1741	0.359
Treatment and surgery fee	226±799	454±1679	0.004	339±1606	504±1840	0.058
Medical examination fee	1210±1355	1663±1737	0.000	1425±2134	1640±1820	0.025
Therapeutic materials	275±661	561±1216	0.000	329±972	608±1712	0.000
Others	179±545	215±574	0.264	218±670	187±499	0.269
Direct non-medical costs	1412±1232	1760±1963	0.000	1654±2069	1703±1915	0.613
Family caregiver transportation fare in hospitalization	185±160	228±254	0.001	217±268	221±248	0.750
Paid care cost in hospitalization	521±449	641±715	0.001	609±753	620±697	0.750
Doctor's labor cost	706±624	891±994	0.000	828±1048	863±970	0.492
Indirect costs	9018±32832	15422±42473	0.004	5707±17578	8932±24592	0.004
Patient productivity loss according to LOS	349±335	421±466	0.002	384±457	399±476	0.526
Family caregiver productivity loss according to LOS	1054±908	1297±1446	0.001	1232±1524	1255±1411	0.750
Patient productivity loss according to ED-LOS	52±45	65±55	0.000	54±48	60±47	0.011
Patient productivity loss according to IHM	7563±32516	13638±42175	0.005	4037±17173	7218±24265	0.004

Supplementary 6. Cost analysis according to age between hospitalist and non-hospitalist groups (N=6391)

	Age ≥ 80yrs (N=1355)		
Cost per patient admission (USD)	**HG (n=363)**	**NHG (n=992)**	***P* value**
Total costs	9310±13469	12453±15958	0.001
Direct costs	5676±6668	6261±5986	0.122
Direct medical costs	4066±5144	4622±4755	0.062
Consultation fee	283±285	268±202	0.298
Admission fee	918±1145	1257±1618	0.000
Medication fee	684±1400	579±929	0.111
Treatment and surgery fee	312±862	352±699	0.377
Medical examination fee	1367±1315	1490±1230	0.109
Therapeutic materials	360±1225	528±1531	0.059
Others	142±284	147±310	0.810
Direct non-medical costs	1610±1801	1639±1452	0.760
Family caregiver transportation fare in hospitalization	211±233	212±188	0.903
Paid care cost in hospitalization	592±655	597±528	0.903
Doctor's labor cost	806±913	830±735	0.627
Indirect costs	3634±9536	6192±13504	0.001
Patient productivity loss according to LOS	364±413	367±352	0.886
Family caregiver productivity loss according to LOS	1199±1326	1207±1069	0.903
Patient productivity loss according to ED-LOS	50±38	56±42	0.026
Patient productivity loss according to IHM	2021±9274	4561±13363	0.001

Data are presented as mean ± standard deviation. HG, hospitalist group; NHG, non-hospitalist group; ED-LOS, emergency department length of stay; LOS,

length of hospital stay; IHM, in hospital mortality; Cost unit: USD (U.S. Dollar), ($1= 1307.9 KRW, year: 2023)

Supplementary 9. Natural log-transformed multivariable regression analysis for medical costs and total costs (N=239)

Variables	Ln(medical costs)			Ln(total costs)		
	coefficient	SE	*P* value	coefficient	SE	*P* value
(constant)	14.601	0.030	0.000	15.641	0.031	0.000
HG (ref= NHG)	-0.355	0.016	0.000	-0.336	0.016	0.000
Female (ref= male)	-0.063	0.012	0.000	-0.064	0.012	0.000
Age	0.001	0.000	0.001	0.004	0.000	0.000
ACCI	0.019	0.003	0.000	0.014	0.003	0.000
KTAS[a] (ref= more urgency)	-0.054	0.018	0.003	-0.024	0.018	0.188
Prior hospitalization history	-0.002	0.001	0.247	0.000	0.001	0.001
LOS	0.034	0.001	0.000	0.033	0.001	0.000
ED-LOS	0.006	0.001	0.000	0.000	0.001	0.000
CPR (ref = No)	-0.170	0.071	0.016	0.042	0.071	0.585
ICU admission (ref = No)	0.711	0.027	0.000	0.684	0.027	0.000
Referral to specialty (ref = No)	0.391	0.017	0.000	0.371	0.017	0.000
Consultation	0.007	0.002	0.000	0.005	0.002	0.006
IHM	0.127	0.024	0.000	0.799	0.024	0.000
Surgical intervention (ref = No)	0.282	0.019	0.000	0.260	0.019	0.000
Major diseases (ref= malignant neoplasms)						
Circulatory system	-0.031	0.025	0.220	0.111	0.025	0.000
Respiratory system	-0.162	0.020	0.000	0.113	0.020	0.000
Digestive system	-0.166	0.021	0.000	0.215	0.021	0.000
Genitourinary system	-0.199	0.024	0.000	0.174	0.024	0.000
Symptoms, signs and abnormal clinical and laboratory findings	-0.068	0.030	0.022	0.117	0.030	0.000
Certain infectious and parasitic diseases	-0.207	0.031	0.000	0.239	0.032	0.000
Endocrine, nutritional and metabolic diseases	-0.330	0.033	0.000	0.238	0.033	0.000
Diseases of the blood and blood- forming organs and certain disorders involving the immune mechanism	-0.062	0.038	0.103	0.138	0.039	0.000
Diseases of the musculoskeletal system and connective tissue	-0.326	0.042	0.000	-0.251	0.042	0.000
Others	-0.200	0.032	0.000	-0.163	0.032	0.000
	Adj- R2 = 0.686, F = 583.730 (p = 0.000)			Adj- R2 = 0.822, F = 1237.748 (p = 0.000)		

HG, hospitalist group; NHG, non-hospitalist group; ACCI, Age-adjusted Charlson Comorbidity Index; KTAS, Korean Triage and Acuity Scale; CPR, Cardio-pulmonary resuscitation; IHM, in-hospital mortality; ICU, intensive care unit; LOS, length of hospital stay; ED-LOS, emergency department length of stay; SE, standard error

"surgical intervention" implies the patient underwent surgery during the hospital stay, not before.

[a]the less urgent group with KTAS = 4–5 was compared to the more urgent group with KTAS = 1–3.

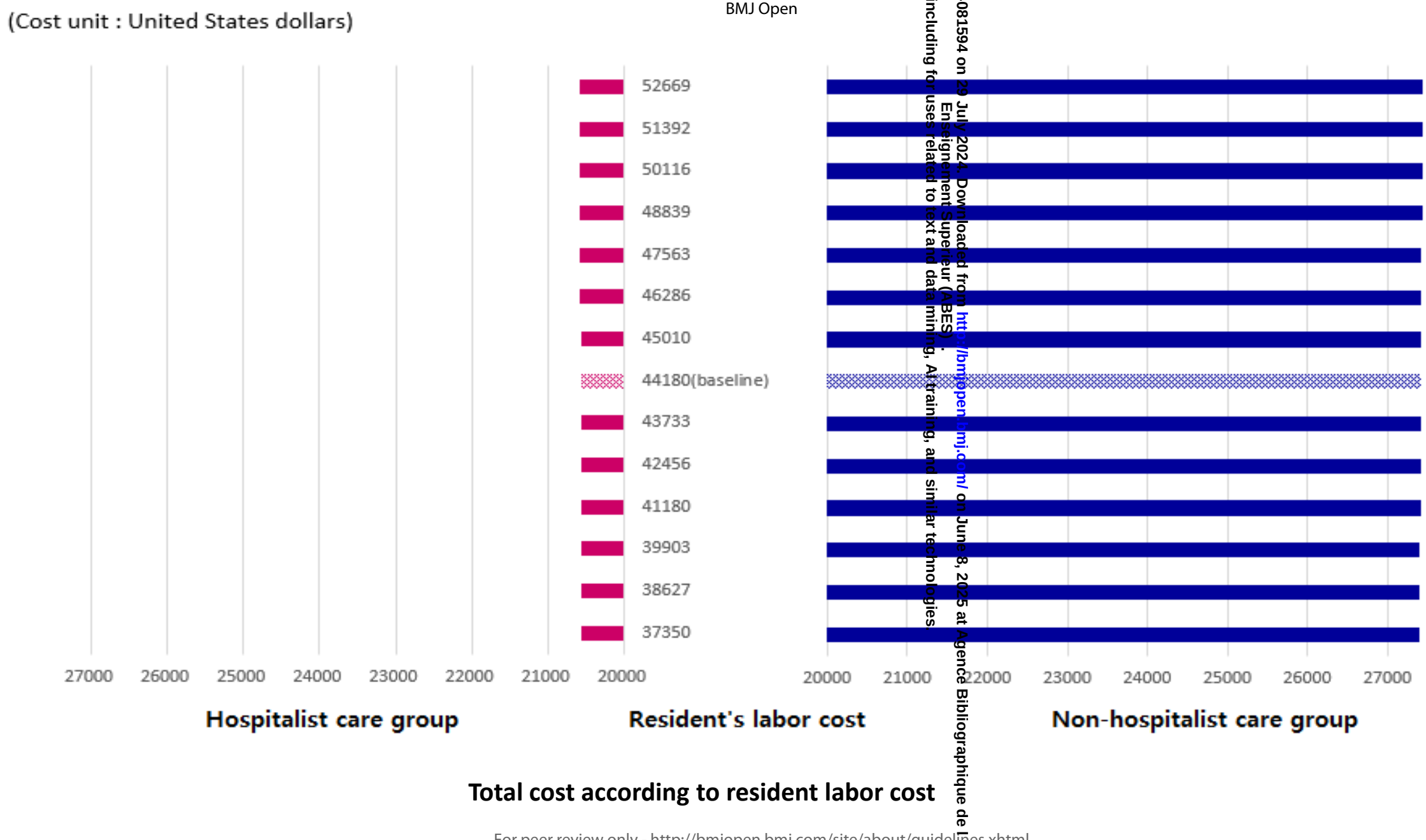
Supplementary 10. Natural log-transformed multivariable regression analysis for direct costs and indirect costs (N=63,991)

Variables	Ln(direct costs)			Ln(indirect costs)		
	coefficient	SE	*P* value	coefficient	SE	*P* value
(constant)	14.946	0.027	0.000	14.582	0.030	0.000
HG (ref= NHG)	-0.336	0.014	0.000	-0.215	0.016	0.000
Female (ref= male)	-0.048	0.011	0.000	-0.026	0.012	0.000
Age	0.001	0.000	0.002	0.009	0.000	0.000
ACCI	0.017	0.003	0.000	0.004	0.003	0.229
KTAS[a] (ref= more urgency)	-0.032	0.016	0.041	-0.009	0.017	0.651
Prior hospitalization history	-0.000	0.001	0.763	0.007	0.001	0.000
LOS	0.038	0.001	0.000	0.044	0.001	0.000
ED-LOS	0.005	0.001	0.000	0.001	0.001	0.000
CPR (ref = No)	-0.186	0.062	0.003	-0.130	0.069	0.004
ICU admission (ref = No)	0.573	0.024	0.000	0.040	0.026	0.127
Referral to specialty (ref = No)	0.400	0.015	0.000	0.294	0.017	0.000
Consultation	0.002	0.001	0.194	0.010	0.002	0.000
IHM	0.063	0.021	0.003	0.119	0.024	0.000
Surgical intervention (ref = No)	0.225	0.017	0.000	0.095	0.019	0.000
Major diseases (ref= malignant neoplasms)						
Circulatory system	-0.055	0.022	0.014	0.238	0.025	0.000
Respiratory system	-0.116	0.018	0.000	0.020	0.020	0.000
Digestive system	-0.163	0.019	0.000	0.215	0.021	0.000
Genitourinary system	-0.150	0.021	0.000	0.035	0.024	0.000
Symptoms, signs and abnormal clinical and laboratory findings	-0.084	0.026	0.001	0.200	0.029	0.000
Certain infectious and parasitic diseases	-0.149	0.028	0.000	0.174	0.031	0.000
Endocrine, nutritional and metabolic diseases	-0.257	0.029	0.000	0.133	0.032	0.000
Diseases of the blood and blood- forming organs and certain disorders involving the immune mechanism	-0.094	0.034	0.005	0.153	0.037	0.000
Diseases of the musculoskeletal system and connective tissue	-0.237	0.037	0.000	-0.133	0.041	0.000
Others	-0.138	0.028	0.000	-0.069	0.031	0.027
	Adj- R2 = 0.726, F = 705.745 (p = 0.000)			Adj- R2 = 0.891, F = 2173.571 (p = 0.000)		

HG, hospitalist group; NHG, non-hospitalist group; ACCI, Age-adjusted Charlson Comorbidity Index; KTAS, Korean Triage and Acuity Scale; CPR, Cardio-pulmonary resuscitation; IHM, in-hospital mortality; ICU, intensive care unit; LOS, length of hospital stay; ED-LOS, emergency department length of stay; SE, standard error

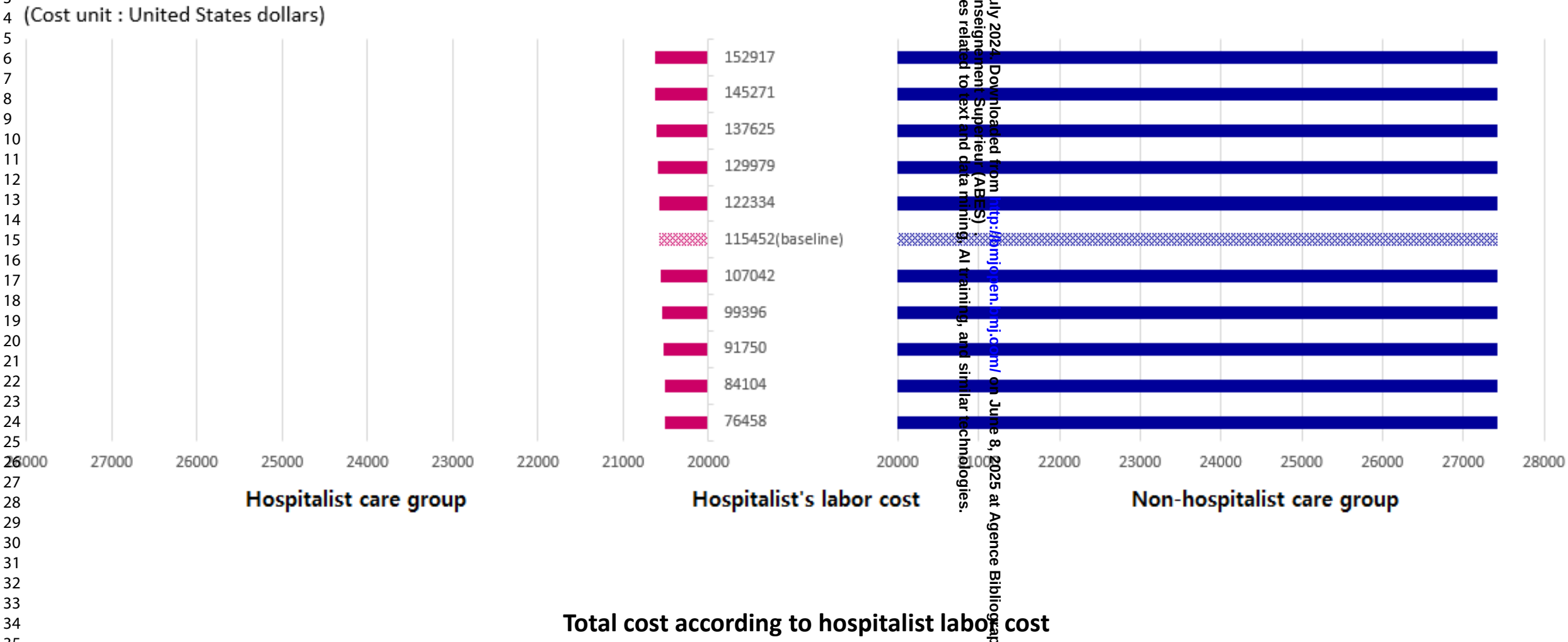
"surgical intervention" implies the patient underwent surgery during the hospital stay, not before.

[a]the less urgent group with KTAS = 4–5 was compared to the more urgent group with KTAS = 1–3.



Supplementary 11. One-way sensitivity analysis for the resident labor cost

Supplementary 12. One-way sensitivity analysis for the specialist labor cost



Supplementary 13. One-way sensitivity analysis for the hospitalist labor cost

Supplementary 14. Two-way sensitivity analysis of net-benefit per patient admission according to doctor labor cost (N=6391)

		Hospitalist labor cost per doctor										
		76458	84104	91750	99396	107042	115452 (baseline)	122334	129979	137625	145271	152917
Resident labor cost per doctor	37350	6905	6893	6880	6867	6855	6841	6830	6817	6804	6792	6779
	38627	6906	6893	6881	6868	6856	6842	6830	6818	6805	6793	6780
	39903	6907	6894	6882	6869	6857	6843	6831	6819	6806	6793	6781
	41180	6908	6895	6883	6870	6857	6843	6832	6820	6807	6794	6782
	42456	6909	6896	6883	6871	6858	6844	6833	6820	6808	6795	6783
	43733	6910	6897	6884	6872	6859	6845	6834	6821	6809	6796	6783
	44180 (baseline)	6910	6897	6885	6872	6859	6846	6834	6822	6809	6796	6784
	45010	6910	6898	6885	6873	6860	6846	6888	6822	6810	6797	6784
	46286	6911	6899	6886	6873	6861	6847	6836	6823	6810	6798	6785
	47563	6912	6899	6887	6874	6862	6848	6836	6824	6811	6799	6786
	48839	6913	6900	6888	6875	6863	6849	6837	6825	6812	6799	6787
	50116	6914	6901	6889	6876	6863	6849	6838	6826	6813	6800	6788
	51392	6915	6902	6889	6877	6864	6850	6839	6826	6814	6801	6789
	52669	6916	6903	6890	6878	6865	6851	6840	6827	6815	6802	6789

Cost unit: USD (US Dollar), ($1 = 1307.9 KRW, year: 2023)

Supplementary 15. Two-way sensitivity analysis of net-benefit per capita according to doctor labor cost (N=6791)

		Hospitalist labor cost per doctor										
		76458	84104	91750	99396	107042	115452 (baseline)	122334	129979	137625	145271	152917
Specialist labor cost per doctor	76458	6829	6816	6803	6791	6778	6764	6753	6741	6728	6715	6703
	84104	6845	6832	6819	6807	6794	6780	6769	6756	6744	6731	6718
	91750	6860	6848	6835	6823	6810	6796	6785	6772	6760	6747	6734
	99396	6876	6864	6851	6839	6826	6812	6801	6788	6841	6763	6750
	107042	6892	6880	6867	6854	6842	6828	6817	6804	6791	6779	6766
	115452 (baseline)	6910	6897	6885	6872	6859	6846	6834	6822	6809	6796	6784
	122334	6924	6912	6899	6886	6874	6860	6848	6836	6823	6811	6798
	129979	6940	6927	6915	6902	6890	6876	6864	6852	6839	6827	6814
	137625	6956	6943	6931	6918	6906	6892	6880	6868	6855	6843	6830
	145271	6972	6959	6947	6934	6921	6908	6896	6884	6871	6858	6846
	152917	6988	6975	6963	6950	6937	6924	6912	6900	6887	6874	6862

Cost unit: USD (U.S. Dollar), ($1= 1307.9 KRW, year: 2023)

CHEERS 2022 Checklist

Topic	No.	Item	Location where item is reported
Title			
	1	Identify the study as an economic evaluation and specify the interventions being compared.	1
Abstract			
	2	Provide a structured summary that highlights context, key methods, results, and alternative analyses.	2
Introduction			
Background and objectives	3	Give the context for the study, the study question, and its practical relevance for decision making in policy or practice.	4
Methods			
Health economic analysis plan	4	Indicate whether a health economic analysis plan was developed and where available.	5
Study population	5	Describe characteristics of the study population (such as age range, demographics, socioeconomic, or clinical characteristics).	5
Setting and location	6	Provide relevant contextual information that may influence findings.	5
Comparators	7	Describe the interventions or strategies being compared and why chosen.	5,6
Perspective	8	State the perspective(s) adopted by the study and why chosen.	4,5
Time horizon	9	State the time horizon for the study and why appropriate.	11
Discount rate	10	Report the discount rate(s) and reason chosen.	11
Selection of outcomes	11	Describe what outcomes were used as the measure(s) of benefit(s) and harm(s).	6
Measurement of outcomes	12	Describe how outcomes used to capture benefit(s) and harm(s) were measured.	6-8
Valuation of outcomes	13	Describe the population and methods used to measure and value outcomes.	6-8
Measurement and valuation of resources and costs	14	Describe how costs were valued.	8-10
Currency, price date, and conversion	15	Report the dates of the estimated resource quantities and unit costs, plus the currency and year of conversion.	8,9,13

Topic	No.	Item	Location where item is reported
Rationale and description of model	16	If modelling is used, describe in detail and why used. Report if the model is publicly available and where it can be accessed.	Not applicable
Analytics and assumptions	17	Describe any methods for analysing or statistically transforming data, any extrapolation methods, and approaches for validating any model used.	11,12
Characterising heterogeneity	18	Describe any methods used for estimating how the results of the study vary for subgroups.	12
Characterising distributional effects	19	Describe how impacts are distributed across different individuals or adjustments made to reflect priority populations.	10,11
Characterising uncertainty	20	Describe methods to characterise any sources of uncertainty in the analysis.	10,11
Approach to engagement with patients and others affected by the study	21	Describe any approaches to engage patients or service recipients, the general public, communities, or stakeholders (such as clinicians or payers) in the design of the study.	12
Results			
Study parameters	22	Report all analytic inputs (such as values, ranges, references) including uncertainty or distributional assumptions.	13-19
Summary of main results	23	Report the mean values for the main categories of costs and outcomes of interest and summarise them in the most appropriate overall measure.	13-19
Effect of uncertainty	24	Describe how uncertainty about analytic judgments, inputs, or projections affect findings. Report the effect of choice of discount rate and time horizon, if applicable.	18
Effect of engagement with patients and others affected by the study	25	Report on any difference patient/service recipient, general public, community, or stakeholder involvement made to the approach or findings of the study	Not applicable
Discussion			
Study findings, limitations, generalisability, and current knowledge	26	Report key findings, limitations, ethical or equity considerations not captured, and how these could affect patients, policy, or practice.	20-23
Other relevant information			
Source of funding	27	Describe how the study was funded and any role of the funder in the identification, design, conduct, and reporting of the analysis	25
Conflicts of interest	28	Report authors conflicts of interest according to journal or International Committee of Medical Journal Editors requirements.	25

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Economic evaluation of the hospitalist care model in an acute medical unit: A benefit-cost analysis

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ABSTRACT

Objective: This study aimed to assess the economic efficiency of the acute medical unit (AMU) hospitalist care model, utilizing patient outcomes (length of hospital stay, emergency department-length of hospital stay, in hospital mortality) from a previous investigation.

Design: A retrospective cohort study was conducted using benefit-cost analysis from a societal perspective. Data relating to clinical factors, outcomes, and medical costs were obtained from the electronic medical record database at our institution. Literature-based costing was applied to determine direct non-medical costs and indirect costs that could not be obtained directly.

Setting: A tertiary care hospital in the Republic of Korea.

Participants: We evaluated 6391 medical inpatients admitted through the emergency department (ED) from June 1, 2016, to May 31, 2017.

Interventions: The study compared multiple types of costs and benefits among inpatients from the ED between a non-hospitalist group and an AMU hospitalist group.

Results: This investigation found a significant reduction in medical costs and total costs in the AMU hospitalist group compared to the non-hospitalist group (29.3% reduction, 95% CI: 27.6–32.1%, *P*=0.000; 30% reduction, 95% CI: 27.0–31.5%, *P*=0.000; respectively). Furthermore, significant reductions in direct and indirect costs were found in the AMU hospitalist group compared to the non-hospitalist group **(**28.6% reduction, 95% CI: 26.6–30.5%, *P*=0.000; 23.3% reduction, 95% CI: 20.9–25.5%, *P*=0.000; respectively). The net-benefit and benefit-cost ratio (BCR) of the AMU hospitalist care group were US $6846 and 1.33 per patient admission, respectively.

Conclusions: The AMU hospitalist care model was associated with remarkable reductions in multiple costs. The results of the sensitivity analysis indicated that the net-benefit estimates of AMU hospitalist care were similar to the baseline estimates. Thus, the overall net-benefit of AMU hospitalist care was found to be largely positive.

Strengths and limitations of this study

- In this study, extensive cost analysis was conducted from a societal perspective.
- The study encompassed all medical inpatients who were admitted from the emergency department to medical wards throughout the specified time frame from June 1, 2016, to May 31, 2017. Having such broad inclusion criteria is likely to have enhanced the validity of the findings.
- Making generalizations regarding this retrospective study is challenging because of its singular institution of origin.
- Expenditures apart from medical costs were not obtained directly but were calculated after consulting relevant sources; therefore, a degree of uncertainty may remain in the cost estimates.
- This study could not quantify the potential benefits associated with a reduction in admissions to the intensive care unit. Therefore, the benefits determined in this study may have been undervalued.

INTRODUCTION

In South Korea, a pilot hospitalist care system was implemented from 2016 to address reduced numbers of medical personnel and improve the quality of inpatient care [1]. The pilot project was integrated within the general hospital care system after 5 years, and the number of hospitalists in Korea has increased to approximately 250 [2]. Under the hospitalist care model, a dedicated specialist takes comprehensive responsibility directly and provides managed care to patients during admission, whereas under the non-hospitalist care model, a resident provides care to patients during admission under the supervision of a specialist.

Since the implementation of the hospitalist care system in Korea, research on patient outcomes has been conducted [3-9] in terms of in-hospital mortality (IHM), intensive care unit (ICU) admission, emergency department-length of stay (ED-LOS), and total length of stay (LOS). Although there have been many studies on the effectiveness of the hospitalist system, few studies have been undertaken on costs or involving economic evaluations. While some studies have reported on the medical costs of hospitalist care in South Korea [7, 10], no economic evaluations from a societal perspective have been reported concerning hospitalist care in South Korea. Therefore, evaluating the economic efficiency of hospitalist care is necessary, considering both its costs and effects in terms of whether it is efficient within the overall medical system. In this study, economic efficiency was defined by a positive net-benefit and benefit-cost ratio (BCR) exceeding 1. Hence, we conducted an economic evaluation that accounted for both costs and benefits for the same patient population whose outcomes had been previously assessed [9].

In this study, a societal-perspective economic evaluation was conducted to estimate the overall costs and benefits of the acute medical unit (AMU) hospitalist care model implemented at our institution, based on patient outcomes. We aimed to provide new evidence on the economic efficiency of the AMU hospitalist care model.

METHODS

Study participants and AMU setting

We evaluated 6391 medical inpatients admitted through the emergency department (ED) of our institution from June 1, 2016, to May 31, 2017, who were assigned to AMU hospitalist care and non-hospitalist care groups (2426 and 3965 patients, respectively). The AMU patients were evaluated and treated by four hospitalists with an average of ten years of clinical experience in infectious diseases, pulmonology and critical care, nephrology, and endocrinology [9]. Seven days per week, two AMU hospitalists were responsible for the care of the AMU patients admitted during the day. In addition, non-hospitalist inpatient care was provided by subspecialists and residents in a specialty medical ward, where residents were primarily responsible for inpatient care under the supervision of an attending physician [9]. While hospitalist care in the AMU focused on general acute care, non-hospitalist care in the specialty medical ward emphasized long-term and specialized treatment [9].

Study design

This retrospective cohort study compared and analyzed the cost-saving benefits, calculated based on costs and patient outcomes, between AMU hospitalist care and non-hospitalist care groups for patients admitted through the ED at a tertiary hospital.

We conducted a benefit-cost analysis and divided costs into medical costs, non-medical costs, and time costs in terms of productivity loss [11]. This investigation was conducted in accordance with Consolidated Health Economic Evaluation Reporting Standards 2022 (CHEERS 2022) [12]. A flow diagram of the study population and benefit-cost factors is presented in Supplementary 1.

Ethics statement

The study protocol was approved by the Institutional Review Board of Seoul National University Bundang Hospital (approval number: B-1711/435-107), and the need for informed consent was waived.

Outcomes and clinical variables

Outcomes and clinical variables were obtained from the electronic medical records (EMRs) at our institution. Among the outcome variables, IHM, LOS, and ED-LOS were used to calculate costs and benefits as well as the time cost of productivity loss. Productivity loss is the time cost incurred as a result of mortality or disease-related restrictions on productive activities due to admission [13].

We analyzed the following clinical variables of the participants: age, sex, prior hospitalization history, cardiopulmonary resuscitation (CPR) incidence, cause of ICU admission, referral to a specialty, consultations, surgical intervention (cases performed during the hospitalization, not before), major diagnosis (based on the International Statistical Classification of Diseases and Related Health Problems, 10th Revision, Australian Modification [ICD-10-AM]), and Korean Triage and Acuity Scale (KTAS), Age-adjusted Charlson Comorbidity Index (ACCI), and Acute Physiology and Chronic Health Evaluation (APACHE) II scores. The ACCI score is derived from the sum of 1, 2, 3, and 6 weighted values for 17 disease groups, ranging from 0 to 29; higher scores indicate higher severity [14]. The KTAS, which is currently applied in emergency medical centers in Korea, is a national standardized classification tool for evaluating illness severity [15]. We used the APACHE II score to compare the disease severity among ICU admissions; this score (range: 0–71) has been found to closely correlate with the risk of hospital death [16]. Baseline characteristics of the study population are presented in Table 1 [9].

Table 1. Baseline characteristics of patients cared for by hospitalists and non-hospitalists (N=6391)

Baseline Characteristics	Hospitalists (n=2426)	Non-hospitalists (n=3965)	*P value*
Sex			
Male	1387 (57.2)	2188 (55.2)	0.120
Female	1039 (42.8)	1777 (44.8)	
Age (years)	63.24±16.20	67.38±16.52	<0.001
<50	488 (20.1)	610 (15.4)	<0.001
50–59	401 (16.5)	499 (12.6)	
60–69	542 (22.3)	733 (18.5)	
70–79	632 (26.1)	1131 (28.5)	
≥80	363 (15.0)	992 (25.0)	
Prior hospitalization	2101 (86.6)	3373 (85.1)	0.090
Number of prior hospitalizations	3.16±4.07	3.24±4.20	0.480
Korean Triage and Acuity Scale			
1 (Resuscitation)	12 (0.5)	69 (1.7)	<0.001
2 (Emergency)	324 (13.4)	941 (23.7)	
3 (Urgent)	1699 (70.0)	2511 (63.3)	
4 (Less urgent)	367 (15.1)	403 (10.2)	
5 (Non-urgent)	24 (1.0)	41 (1.0)	
Major disease			
Malignant neoplasms	845 (34.8)	890 (22.4)	<0.001
Diseases of the circulatory system	48 (2.0)	552 (13.9)	
Diseases of the respiratory system	266 (11.0)	875 (22.1)	
Diseases of the digestive system	441 (18.2)	424 (10.7)	
Diseases of the genitourinary system	202 (8.3)	375 (9.5)	
Symptoms, signs, and abnormal clinical and laboratory findings	162 (6.7)	167 (4.2)	
Certain infectious and parasitic diseases	86 (3.5)	204 (5.1)	
Endocrine, nutritional, and metabolic diseases	95 (3.9)	158 (4.0)	
Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism	130 (5.4)	47 (1.2)	
Diseases of the musculoskeletal system and connective tissue	58 (2.4)	89 (2.2)	
Others	93 (3.8)	184 (4.6)	
Age-adjusted Charlson Comorbidity Index	3.82±2.63	3.77±2.19	
Median [IQR]	4 [2–5]	4 [2–5]	0.055
≤2	729 (30.0)	1018 (25.7)	0.001
3	436 (18.0)	733 (18.5)	
4	502 (20.7)	943 (23.8)	
≥5	759 (31.3)	1271 (32.1)	
Surgical intervention	282 (11.6)	560 (14.1)	0.004

Baseline Characteristics	Hospitalists (n=2426)	Non-hospitalists (n=3965)	*P value*
CPR incidence	15 (0.6)	35 (0.9)	0.244
Consultation	1830 (75.4)	2946 (74.3)	0.312
Number of consultations	3.50±6.18	3.99±7.02	0.004
Referral to a specialty	1613 (66.5)	450 (11.3)	<0.001
Type of specialty referral (n=2063)			
Hematology & Oncology	658 (40.8)	114 (25.3)	<0.001
Gastroenterology	360 (22.3)	20 (4.4)	
Respiratory	174 (10.8)	53 (11.8)	
Nephrology	96 (6.0)	11 (2.4)	
Infection	96 (6.0)	8 (1.8)	
Geriatrics	80 (5.0)	9 (2.0)	
Others	149 (9.2)	235 (52.2)	
Outcomes			
In-hospital mortality	117 (4.8)	361 (9.1)	<0.001
ICU admission	95 (3.9)	343 (8.7)	<0.001
Cause of ICU admission (n=438)			
Close monitoring after procedure or surgical intervention	55 (57.9)	223 (65.0)	0.077
Respiratory failure or insufficiency	23 (24.2)	78 (22.7)	
Septic shock	7 (7.4)	17 (5.0)	
Cardiovascular failure or insufficiency	7 (7.4)	12 (3.5)	
Metabolic/Renal failure	0 (0.0)	8 (2.3)	
GI bleeding	3 (3.2)	2 (0.6)	
Neurogenic dysfunction	0 (0.0)	3 (0.9)	
APACHE II score at ICU admission (n=438)	25.20±10.62	21.26±12.03	0.004
Length of hospital stay (days)	10.56±11.68	11.40±12.36	
Median [IQR]	7 [4–12]	8 [5–13]	0.007
ED-LOS (hours)	11.24±8.49	13.74±10.11	
Median [IQR]	8.4 [6.1–12.7]	10.2 [6.7–19.0]	<0.001
Re-admission within 10 days	117 (4.8)	177 (4.5)	0.507
Re-admission within 30 days	277 (11.4)	416 (10.5)	0.248

Data are presented as the mean ± standard deviation, number (%), or median [IQR], as indicated.
"Surgical intervention" implies the patient underwent surgery during the hospital stay, not before.
IQR, interquartile range; CPR, cardiopulmonary resuscitation; ICU, intensive care unit; APACHE, Acute Physiology and Chronic Health Evaluation; ED-LOS, emergency department-length of stay

Cost measures

Micro-costing and gross-costing were used for cost calculation in this study. Micro-costing was applied to directly calculate the medical costs during the total hospital stay [17]. Gross-costing was used

to calculate all costs other than medical costs (Supplementary 2). The costs were classified into direct costs and indirect costs [13], with all unit costs converted to United States (US) dollars as of 2023.

Direct costs

Direct costs comprised medical costs (micro-costing), family caregiver transportation fares, paid care costs, and doctor labor costs in hospitalization (gross-costing). Healthcare in South Korea is a single-payer system organized through the National Health Insurance Service (NHIS). Nearly all citizens receive universal medical care through this system [18]. The governance of National Health Insurance in South Korea is presented in Supplementary 3. The health security system in Korea has two components: mandatory social health insurance and medical aid. In Korea, fee-for-service has been the standard payment model for outpatient care and the majority of inpatient care, leading to an increase in the volume of services that healthcare professionals can provide [19]. Medical costs in this study comprised reimbursements issued to medical providers by the NHIS and co-payments paid to medical providers by patients.

Medical cost data were obtained from hospital administrative information in the EMRs at our institution regarding consultation fee, admission fee (mainly hospital room expense, including for isolation, intensive care, and general hospital room), medication fee (medication / injection / anesthesia / whole blood and blood product), treatment and surgery fee, medical examination fee (inspection / medical imaging / computed tomography / magnetic resonance imaging / positron emission tomography / ultrasonography), therapeutic materials, and other factors (prosthetics, orthodontics / rehabilitation and physiotherapy / psychotherapy).

The family caregiver transportation fare in relation to hospitalization was estimated by multiplying referenced costs (2017 Korea Health Panel Study [20] and the 2017 Consumer Price Index [21]) by individual patient's LOS. The term "family caregiver transportation costs" referred to the mean expenses for round-trip transportation for each visit of a family caregiver to a medical facility during the patient's hospitalization [20]. The paid care cost was calculated by multiplying the referenced

average costs [22] by individual patient's LOS. During the day, hospitalists administer care to patients in the hospitalist care group while residents provide care under the direction of a subspecialist. During the night, residents care for patients in both groups. The daytime doctor labor costs were estimated and analyzed separately for residents, subspecialists, and hospitalists (Supplementary 2 and 4). Resident doctor labor costs per patient were estimated using the following variables: the average after-tax salary (2017 resident training environment evaluation survey results [23]), four major social insurance scheme classifications (national pension, health insurance, employment insurance, and workers' compensation insurance [24]) and tax (income tax and resident tax [25]), the number of inpatients per physician [26], and the total patient days (the total number of days for all inpatients) in the non-hospitalist care group. Subspecialist labor costs were calculated using a referenced average labor cost [27], the number of inpatients per physician [28, 29], and the total patient days in the non-hospitalist care group.

The AMU hospitalist labor costs per patient were calculated using a referenced average labor cost [30], the number of AMU hospitalists, and AMU-LOS in the hospitalist care group. In addition, doctor labor costs for night shifts were estimated by reflecting the number of patients under the charge of residents [31], residents' average wage, and total patient days in the non-hospitalist care group.

Indirect costs

Indirect costs (time costs) were calculated by applying the gross-costing method. Patient productivity loss during hospitalization (time costs) was calculated by multiplying the average daily wage by gender and age [32], by individual LOS, and by the labor force participation rate [33]. Family caregiver productivity loss was calculated by multiplying the average daily wage of all workers [32] by individual LOS. Patient productivity loss due to ED-LOS was calculated by multiplying the average hourly wage by gender and age [32], by individual ED-LOS, and by the labor force participation rate [33]. Patient productivity loss due to death in hospitalization was calculated by multiplying the average annual wage by gender and age [32], by the labor force participation rate [33], and by individual life years gained in relation to death [34]. Individual life years gained were estimated by subtracting life expectancy reduced

by major diseases from life expectancy by gender and age, in reference to life tables available from the Korean Statistical Information Service (KOSIS, 2017) [34].

Benefit measure

In this study, the human capital approach was used as a method of evaluating the value of "health" or "life" in monetary units [17]. Benefits, in the form of cost savings, were then estimated based on direct and indirect costs.

Economic evaluation: benefit-cost analysis

In benefit-cost analysis, the BCR and net-benefit are used as indicators for decision indices. Net-benefit refers to the benefit minus the cost, with a larger net-benefit indicating a more favorable benefit-cost situation [17]. Therefore, we used BCR and net-benefit as indicators in terms of decision indices.

Sensitivity analysis

This study is a retrospective study of costs incurred. As the study period comprised only one year, a discount rate was not applied to the costs and a sensitivity analysis was performed on uncertain variables [35]. The results of the sensitivity analysis are presented in a tornado diagram (Figure 1).

First, a sensitivity analysis was conducted on LOS and ED-LOS, which showed a skewed distribution. We analyzed the 1%-trimmed mean by calculating the average of the remaining values while excluding some (1%) from the extremes of the data.

Second, a sensitivity analysis was conducted on paid care costs among the direct non-medical costs that were considered to have high uncertainty. Assuming that no caregiver was hired, the baseline paid care costs were set at $53 [22], and the maximum daily paid care costs for hospitalized patients were set at $122 [22].

Third, a sensitivity analysis was conducted on doctor labor costs among the direct non-medical costs

that were considered to have high uncertainty, with both one-way and two-way sensitivity analyses conducted. Resident labor costs were set at $44,180 as a baseline, with a minimum value of $37,350 and a maximum value of $52,669 [23]. Hospitalist and specialist labor costs were set at $115,452 as a baseline [27, 30], with a minimum value of $76,458 and a maximum value of $152,917.

Statistical analysis

Categorical variables are reported as percentages, and continuous variables as mean ± standard deviation (SD). Groups were compared by conducting Pearson's chi-square tests or t-tests, as appropriate. ACCI, LOS, and ED-LOS were expressed as the median and interquartile range (IQR). For these variables, groups were compared by conducting the Mann–Whitney *U* test, owing to their skewed distributions. We performed subgroup analyses of costs and benefits according to age, the severity of the patient's condition (based on the KTAS score), the degree of comorbidity (based on the ACCI score), and the major disease category (based on the ICD-10). Natural log-transformed multivariable regression analysis was conducted in relation to the costs. As the unit cost was large, using a natural logarithm can increase normality and enable accurate values to be obtained during analysis as well as reduce skewness and kurtosis of the data. Regression analysis for the costs was used to adjust for the following factors: age, sex, prior hospitalization, referral to specialty, consultation, CPR, KTAS score, ACCI score, surgical intervention, major disease, ICU admission, IHM, LOS, and ED-LOS. Using the estimates from the regression models, we presented differences between AMU hospitalized and non-hospitalized groups in terms of medical, direct, indirect, and total costs.

Patient and public involvement

This was a non-interventional study conducted retrospectively. Consequently, no patients participated directly in the study's conception, formulation of research objectives and queries, or execution. In addition, patients were not involved in the interpretation of results or production of the manuscript. It is not currently in our intentions to disseminate the findings to the study participants.

RESULTS

Costs

All costs are presented as costs per patient admission in this study. The estimated costs (US $1 = 1307.9 KRW, year: 2023 [36]) between the hospitalist group and the non-hospitalist group are presented in Table 2. The total costs were significantly lower in the hospitalist group than in the non-hospitalist group, with a difference of more than $6000 (20570±91024 *vs.* 27416±102360, *P*=0.007). The direct medical costs were significantly lower in the hospitalist group than in the non-hospitalist group, with a difference of more than $900 (4075±6504 *vs*. 5050±7255, *P*= 0.000).

Among the subcategories of medical costs, the biggest difference was found in relation to the admission fee and medical examination fee (886±1661 *vs.* 1167±1697, *P*=0.003; 1269±1629 *vs.* 1565±1676, *P*=0.000; respectively). Among the direct non-medical costs, the family caregiver transportation fare, paid care costs, and doctor labor costs were significantly lower in the hospitalist group than in the non-hospitalist group (*P*=0.007, *P*=0.007, and *P*=0.000; respectively).

The indirect costs were significantly lower in the hospitalist group than in the non-hospitalist group, with a difference of more than $5000 (14988±89375 *vs.* 20719±100689, *P*=0.021). Among the indirect costs, family caregiver productivity loss according to LOS and patient productivity loss according to ED-LOS and IHM were significantly lower in the hospitalist group than in the non-hospitalist group (*P*=0.007, *P*=0.000, and *P*=0.023, respectively). However, there were no significant differences between the two groups in terms of patient productivity loss according to LOS (560±782 *vs.* 549±788, *P*=0.570).

Table 2. Costs of patients cared for by hospitalists and non-hospitalists (N=6391)

Cost per patient admission (USD)	HG (n=2426)	NHG (n=3965)	*P* value
Total costs	20570±91024	27416±102360	0.007
Direct costs	5582±8003	6697±8729	0.000
Direct medical costs	4075±6504	5050±7255	0.000
Consultation fee	251±221	269±238	0.003
Admission fee	886±1661	1167±1697	0.000
Medication fee	907±2345	889±2324	0.774
Treatment and surgery fee	266±1092	432±1720	0.000
Medical examination fee	1269±1629	1565±1676	0.000
Therapeutic materials	304±866	552±1477	0.000
Others	191±596	176±467	0.249
Direct non-medical costs	1508±1688	1647±1786	0.002
Family caregiver transportation fare in hospitalization	198±219	213±231	0.007
Paid care cost in hospitalization	556±614	600±650	0.007
Doctor's labor cost	754±855	834±904	0.000
Indirect costs	14988±89375	20719±100689	0.021
Patient productivity loss according to LOS	560±782	549±788	0.570
Family caregiver productivity loss according to LOS	1124±1243	1213±1316	0.007
Patient productivity loss according to ED-LOS	76±75	86±90	0.000
Patient productivity loss according to IHM	13228±88992	18871±100401	0.023

Data are presented as mean ± standard deviation. HG, hospitalist group; NHG, non-hospitalist group; ED-LOS, emergency department-length of stay; LOS, length of hospital stay; IHM, in-hospital mortality; Cost unit: USD (US Dollar), ($1 = 1307.9 KRW, year: 2023)

Subgroup cost differences according to KTAS scores, comorbidity severity, major disease, and age

Cost analysis was performed according to subgroups of patients stratified by KTAS scores, ACCI scores, major disease, and age to determine differences between the two groups (Supplementary 5, 6, 7, and 8). Compared to the non-hospitalist group, the hospitalist group's overall costs for more urgent cases were significantly reduced by more than $8000 (*P*=0.002). In low-to-moderate comorbidity groups (ACCI = 0–2, 3, and 4 points), there was a greater cost reduction in the hospitalist group than in the non-hospitalist group ($12941, *P*=0.033; $10017, *P*=0.152; $8199, *P*=0.016; respectively).

Among the major diseases, in all but three disease types, the overall cost in the hospitalist group decreased compared to the non-hospitalist group (Supplementary 7). In a subgroup analysis by age, total costs in the hospitalist group decreased in almost all age groups (*P*=0.248, *P*=0.004, *P*=0.000, *P*=0.002, *P*=0.001, respectively).

Natural log-transformed multivariable regression analysis of costs

We performed natural log-transformed multivariable regression analysis to adjust for clinical variables and outcome variables potentially associated with costs, namely, medical, direct, indirect, and total costs (Supplementary 9 and 10). Regression analysis revealed a significant 30% reduction in medical costs and a 29.3% reduction in total costs in the hospitalist group compared to the non-hospitalist group ($e^{-0.355}$=0.701, *P*=0.000; $e^{-0.346}$=0.707, *P*=0.000; respectively). Furthermore, there was a significant reduction of 28.6% in direct costs and a 23.3% reduction in indirect costs in the hospitalist group compared to the non-hospitalist group (**(**$e^{-0.336}$=0.714, *P*=0.000; $e^{-0.265}$=0.767, *P*= 0.000; respectively).

Benefit-cost analysis

Net-benefit and BCR analysis were conducted according to the total group and subgroups of patients stratified by clinical variables, KTAS scores, ACCI scores, major diagnoses, and age (Table 3). Among

the total group of patients, the net-benefit and BCR of the AMU hospitalist care group were $6846 and 1.33 per patient admission, respectively; overall net-benefit of AMU hospitalist care was found to be largely positive. Among the patients stratified by clinical variables, net-benefit and BCR of AMU hospitalist care were found to be largely positive in all but five 5 subgroups (less urgent; ACCI ≥5; diseases of the circulatory system; diseases of the genitourinary system; and endocrine, nutritional, and metabolic diseases).

Table 3. Benefit-cost analysis

Total Cost per patient admission (USD)	HG (A)	NHG (B)	Net-benefit (B-A)	B/A ratio (benefit cost ratio, BCR)
Total (N=6391)	20570	27416	6846	1.33
KTAS				
More urgency (n=5556)	20334	29074	8740	1.43
Less urgency (n=835)	21801	14269	-7532	0.65
ACCI				
ACCI ≤2 (n=1747)	16700	29640	12941	1.77
ACCI=3 (n=1169)	24948	34965	10017	1.40
ACCI=4 (n=1445)	14346	22545	8199	1.57
ACCI≥5 (n=2030)	25890	24894	-996	0.96
Major disease				
Malignant neoplasms (n=1735)	37059	63186	26127	1.71
Diseases of the circulatory system (n=600)	21568	10963	-10604	0.51
Diseases of the respiratory system (n=1141)	12369	18568	6199	1.50
Diseases of the digestive system (n=865)	10408	19732	9324	1.90
Diseases of the genitourinary system (n=577)	14018	11979	-2039	0.85
Symptoms, signs, and abnormal clinical and laboratory findings (n=329)	6724	10762	4038	1.60
Certain infectious and parasitic diseases (n=290)	5411	22358	16947	4.13
Endocrine, nutritional, and metabolic diseases (n=253)	13906	5765	-8142	0.41
Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism (n=177)	12512	65460	52948	5.23
Diseases of the musculoskeletal system and connective tissue (n=147)	9269	19916	10647	2.15
Others (n=277)	19377	28223	8846	1.46
Age (years)				
<50 (n=1098)	34234	46473	12238	1.36
50–59 (n=900)	36276	66967	30691	1.85
60–69 (n=1275)	14345	22699	8354	1.58
70–79 (n=1763)	11861	15868	4007	1.34
≥80 (n=1355)	9310	12453	3143	1.34

Data are presented as mean. HG, hospitalist group; NHG, non-hospitalist group; KTAS, Korean Triage and Acuity Scale; ACCI, Age-adjusted Charlson Comorbidity Index; Cost unit: USD (US Dollar), ($1 = 1307.9 KRW, year: 2023)

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Sensitivity analysis

The sensitivity analysis results for LOS and ED-LOS are shown in Figures 1-1 and 1-2. We analyzed the 1%-trimmed mean and excluded patients with extreme values, as noted. After excluding extreme values related to LOS, the results were stable (net-benefit: $7162 to $8067, BCR: 1.31 to 1.33) and showed no significant difference from the baseline analysis. Sensitivity analysis for ED-LOS revealed that the results were similar to (net-benefit: $6311 to $6846, BCR: 1.31 to 1.33) the baseline analysis. After varying paid care costs from $0 to $122, the sensitivity analysis results were stable, with the net-benefit ranging from $8013 to $8138 and the BCR from 1.32 to 1.34 (Figure 1-3). One-way sensitivity analysis results showed comparative values of resident, specialist, and hospitalist labor costs (Supplementary 11,12, and 13), with resident labor costs ranging from $37,350 to $52,669, which indicated a net-benefit ranging from $6841 to $6851 (BCR, 1.33) (Supplementary 11). After varying specialist labor costs from $76,458 to $152,917, the results were similar to baseline estimates, with net-benefit ranging from $6764 to $6924 (BCR, 1.33) (Supplementary 12).

After varying hospitalist labor costs from $76,458 to $152,917, the results were stable, with the net-benefit ranging from $6784 to $6910 (BCR, 1.33) (Supplementary 13).

Two-way sensitivity analysis results on hospitalist and resident labor costs showed that net-benefit ranged from $6779 to $6916 and BCR from 1.33 to 1.34 (Supplementary 14). Moreover, two-way sensitivity analysis results on hospitalist and specialist labor costs showed that net-benefit ranged from $6703 to $6988 and BCR from 1.33 to 1.34 (Supplementary 15).

DISCUSSION

Study summary

This study is the first to report on the economic efficiency of a Korean AMU hospitalist care model while controlling for clinical factors. We found a notable cost reduction with AMU hospitalist care compared to non-hospitalist care in all areas: medical costs, direct costs, indirect costs, and total costs. In this study, medical costs included hospitalist care fees. The same trend toward cost reduction was

observed in the subgroup and regression analyses. In this study, the cost of doctor labor was estimated separately for each hospitalization flow and day and night shifts (Supplementary 4).

The net-benefit and BCR analysis results of the AMU hospitalist care group were $6846 and 1.33 per patient admission, respectively; overall, the net-benefit of AMU hospitalist care was found to be largely positive. Sensitivity analysis showed that the net-benefit and BCR results of AMU hospitalist care were similar to baseline analysis.

In the present resident training system, which lacks a structured curriculum, training has taken the form of encountering more patients and accumulating experience over time. Many institutions still use the apprenticeship model of training to become specialists. The Medical Resident Act has been enacted to address this issue; however, the situation remains ambiguous in the field [37]. Moreover, residents who rotate annually or monthly will inevitably experience strained relationships with other professional teams, and medical treatment is frequently interrupted due to complications such as doctor–nurse disputes [2]. However, direct, real-time communication among our multidisciplinary team members, which enables appropriate and quick decision-making on treatments for patients with acute diseases, is a key component of our AMU care [3].

Furthermore, consultation, formulation, and implementation of treatment plans and the treatment itself are responsibilities shared among residents, fellows, and attending specialists in the context of resident/attending specialist care. However, hospitalists carry the sole responsibility for all these tasks [38]. Moreover, hospitalists have extensive knowledge and proficiency in managing patients who are hospitalized. Their level of professionalism is unparalleled compared to that of residents with 1–2 years of experience, as evidenced by their critical thinking skills, patient communication capabilities, and accountability for treatment [38]. Consequently, these characteristics are believed to help reduce overall costs, including medical costs.

Furthermore, our previous study reported that AMU hospitalist care improved patient outcomes in terms of IHM, ICU admission rate, LOS, and ED-LOS [9]. This enhanced performance may have led to a reduction in indirect expenses and productivity loss.

Direct medical costs

Some previous studies that investigated the costs of hospitalist care have reported reduced medical costs in hospitalist care [10, 39-46]. In contrast, other studies have reported no significant difference in total medical costs between patients treated by hospitalists and those treated by non-hospitalists [7, 47] and that the costs of care for hospitalists were more than those for specialists but less than those for generalists [48]. Our study showed that there was a marked cost reduction in consultation, admission, treatment and surgery, medical examination, and therapeutic materials fees among the medical cost subcategories. Even when hospitalist care fees were included in medical costs, the hospitalist group's medical costs were lower, which indicates that the difference would be even greater if hospitalist care fees were excluded. Among the previous studies, one study that evaluated Korean hospitalists reported that medical costs reduced by $208 in terms of hospitalist care [10]. However, in our study, medical expenses per admission decreased by nearly $1000 in the hospitalist care group. The findings of research on medical cost reduction are consistent, but our study's findings on cost-reduction suggest a more substantial reduction is involved.

The patient group in our study consisted of patients with acute medical conditions admitted through the ED of a tertiary general hospital, with their disease severity being higher than that among those in the total group of patients, which may explain the difference in study results. However, the regression analyses showed a significant 30% reduction in medical costs in the hospitalist group after adjusting for clinical factors. Despite the conflicting results reported in earlier studies, our research findings offer compelling evidence supporting the effectiveness of the AMU hospitalist care model in reducing medical costs.

Direct non-medical costs compared with indirect costs

Studies are lacking on the economic implications of hospitalist care from a societal perspective. Hence, we conducted an estimation and analysis of non-medical expenses to assess the economic feasibility of AMU hospitalist care from a societal perspective.

In a previous study, we reported that AMU hospitalist care considerably improved patient outcomes in terms of IHM, ICU admission rate, LOS, and ED-LOS [9]. In this study, we used patient outcomes from that study to estimate the following costs: family caregiver transportation fares in hospitalization, paid care costs in hospitalization, patient productivity loss based on LOS, family caregiver productivity loss based on LOS, patient productivity loss based on ED-LOS, and patient productivity loss based on IHM.

The hospitalist care group's decreased LOS resulted in a notable reduction in expenses related to family caregiver transportation and paid care during patient hospitalization.

With the exception of patient productivity loss based on LOS, substantial reductions in expenses were shown for family caregiver productivity loss based on LOS and patient productivity loss based on ED-LOS and IHM. The hospitalist group exhibited a considerably reduced LOS in comparison to the non-hospitalist group [9]. However, it is possible that the lower age of the patients in the hospitalist group may account for the larger patient productivity loss based on the LOS observed in this group. Nevertheless, AMU hospitalist care resulted in notable reductions in the indirect costs, surpassing $7000 in savings when compared to the non-hospitalist group. This improvement in patient outcomes played a pivotal role in achieving these cost reductions. Therefore, the overall costs in relation to the AMU hospitalist care group showed a notable decrease in comparison to the non-hospitalist group.

Benefit-cost analysis

The net-benefit and BCR analysis of the AMU hospitalist care group yielded results of $6846 and 1.33 per patient admission, respectively, indicating that the overall net-benefit of AMU hospitalist care was found to be largely positive. However, variations in net-benefit and BCR analysis ranges were seen across different subgroups (-$10604 to $52948, 0.41 to 5.23; respectively). This indicates that the economic efficacy of AMU hospitalist care varies based on the clinical characteristics of patients. Nevertheless, in terms of net-benefit and BCR results, the overall net-benefit of AMU hospitalist care was found to be largely positive in 17 subgroups and negative in five subgroups (less urgent; ACCI ≥5;

diseases of the circulatory system; diseases of the genitourinary system; and endocrine, nutritional, and metabolic diseases). It is possible that this population has a greater demand for specialized care; furthermore, treatment modalities and expenses can vary substantially based on the reason for admission even for the same disease. In our study, clinical variables were adjusted for factors such as age, severity, the major disease, and KTAS. To determine the precise reason for the negative results reported in these five groups, more research into the variables leading to hospitalization or disease-specific clinical outcomes is required.

These findings might potentially serve as a valuable reference for the development of a more efficient hospitalist care paradigm in further research.

A one-way sensitivity analysis was conducted to examine the impact of variations in the LOS, ED-LOS, paid care costs, and doctor labor costs. The net-benefit and BCR analysis results of AMU hospitalist care were stable based on a one-way sensitivity analysis using these four variables. The results of a two-way sensitivity analysis indicated that the net-benefit and BCR results of AMU hospitalist care were similar to the baseline estimates despite fluctuations in labor costs for the resident, specialist, and hospitalist.

Limitations

This study had some limitations. First, it employed a retrospective design, which posed challenges in mitigating the effect of confounding factors and discerning whether the observed results were attributable to the AMU environment or the treatment administered by the hospitalists. Second, the study was conducted at a single site, which limits the extent to which our findings may be generalized. Third, other expenditures, excluding medical expenses, were not directly obtained but rather calculated by consulting relevant sources, which introduced a degree of uncertainty into the cost estimations. Fourth, the present study could not provide a quantifiable assessment of the potential benefits associated with the reduction of ICU admissions. Five, the value and benefits of teaching services were not evaluated in this study. Even if costs are higher for teaching services than for non-teaching services,

training future physicians is a valuable goal. Hence, further investigation to ascertain the value and benefits of teaching services from a societal perspective is required.

CONCLUSION

This study showed that AMU hospitalist care significantly reduced costs in nearly all categories, including medical costs, direct costs, indirect costs, and total costs. Moreover, in the benefit-cost analysis, the net-benefit and BCR results of the AMU hospitalist care group were shown to be greater than $6000 and 1.30 per patient admission, respectively. These results indicate that the overall net-benefit of AMU hospitalist care is largely positive. Nevertheless, further investigation is necessary to identify the factors that contribute to hospitalization or disease-specific clinical outcomes.

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Author Contributions

Conceptualization: Kim HJ, Kim JH, Ohn JH, Kim N-H. Methodology: Kim HJ, Kim JH, Ohn JH, Kim N-H. Software: Kim HJ. Validation: Kim HJ, Kim JH, Ohn JH, Kim N-H. Formal analysis: Kim HJ. Investigation: Kim HJ, Kim JH, Ohn JH, Kim N-H. Data curation: Kim HJ. Writing – original draft: Kim HJ. Writing - review & editing: Kim HJ, Kim JH, Ohn JH, Kim N-H. All authors have read and approved the final draft of the manuscript. JK is the guarantor.

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Competing interests

The authors have no potential conflicts of interest to disclose.

Patient consent for publication

Not applicable.

Ethics approval

Ethical approval was provided by the Institutional Review Board of Seoul National University Bundang Hospital (IRB No. B-1711/435-107). Our institution's ethics committee waived the need for informed consent owing to the retrospective nature of the study and the use of anonymized data previously collected for routine clinical care.

Data availability statement

Data are available from the corresponding author upon reasonable request.

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Figures

Figure 1. One-way sensitivity analysis for the length of hospital stay, emergency department-length of stay, and paid care cost

Supplementary Materials

Supplementary 1. Flow diagram of the study population and benefit-cost factors

Supplementary 2. Type of costs, cost estimation formula, and data source

Supplementary 3. Governance of National Health Insurance in South Korea

Supplementary 4. Doctor labor cost estimation by patient flow and timeline

Supplementary 5. Cost analysis for urgent and non-urgent cases treated by hospitalists or non-hospitalists (N=6391)

Supplementary 6. Cost analysis for patients with different comorbidity severities treated by hospitalists or non-hospitalists (N=6391)

Supplementary 7. Cost analysis according to major diseases between hospitalist and non-hospitalist groups (N=6391)

Supplementary 8. Cost analysis according to age between hospitalist and non-hospitalist groups (N=6391)

Supplementary 9. Natural log-transformed multivariable regression analysis for medical costs and total costs (N=6391)

Supplementary 10. Natural log-transformed multivariable regression analysis for direct costs and indirect costs (N=6391)

Supplementary 11. One-way sensitivity analysis for resident labor costs

Supplementary 12. One-way sensitivity analysis for hospitalist labor costs

Supplementary 13. One-way sensitivity analysis for specialist labor costs

Supplementary 14. Two-way sensitivity analysis for hospitalist and resident labor costs

Supplementary 15. Two-way sensitivity analysis for hospitalist and specialist labor costs

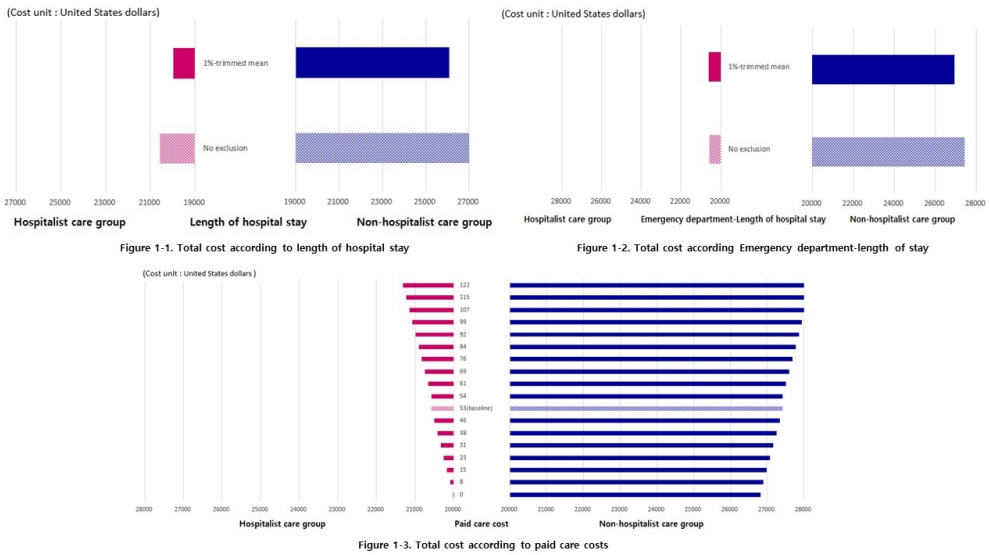

Figure 1. One-way sensitivity analysis for the length of hospital stay, emergency department-length of stay, and paid care cost

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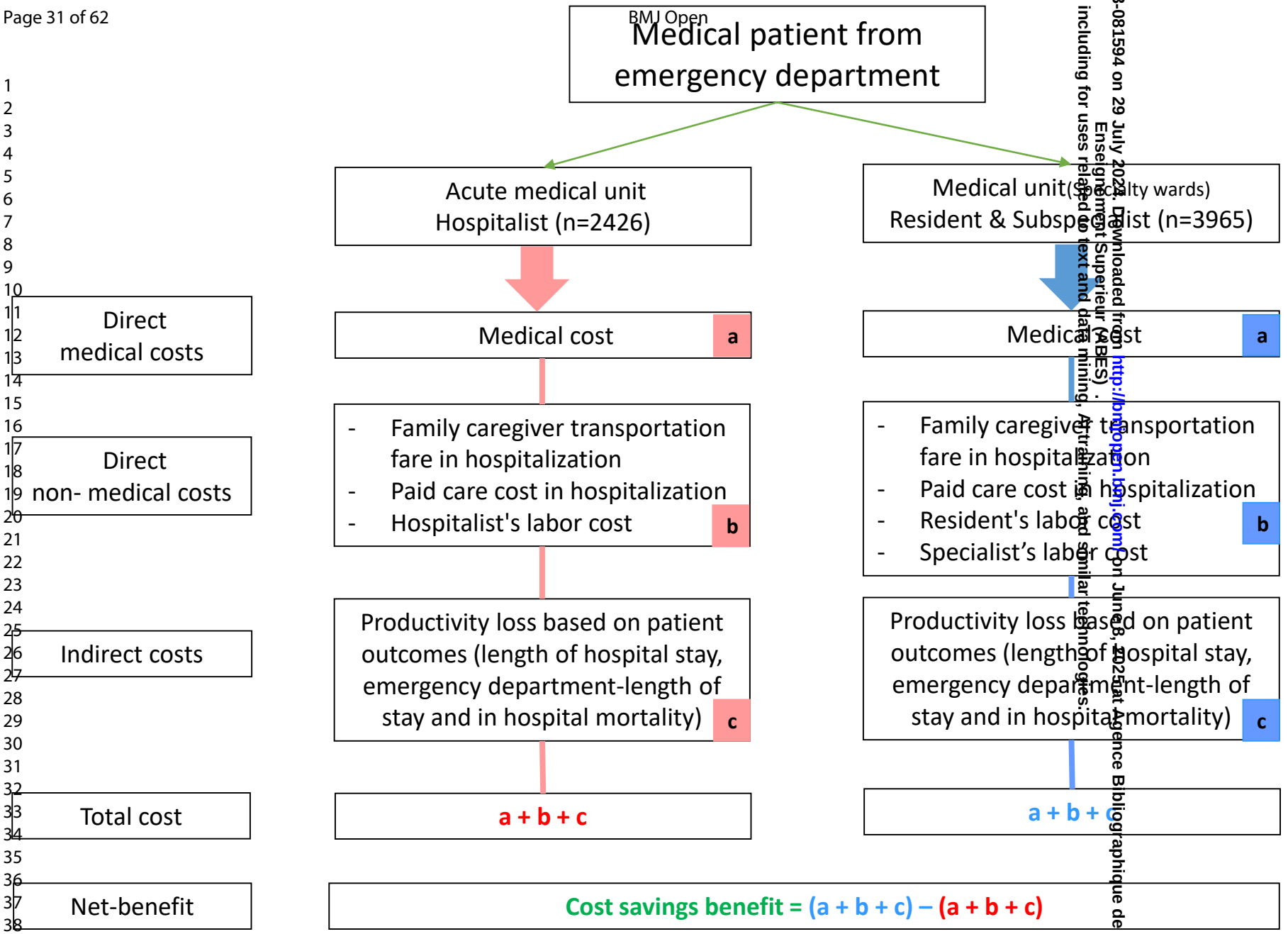


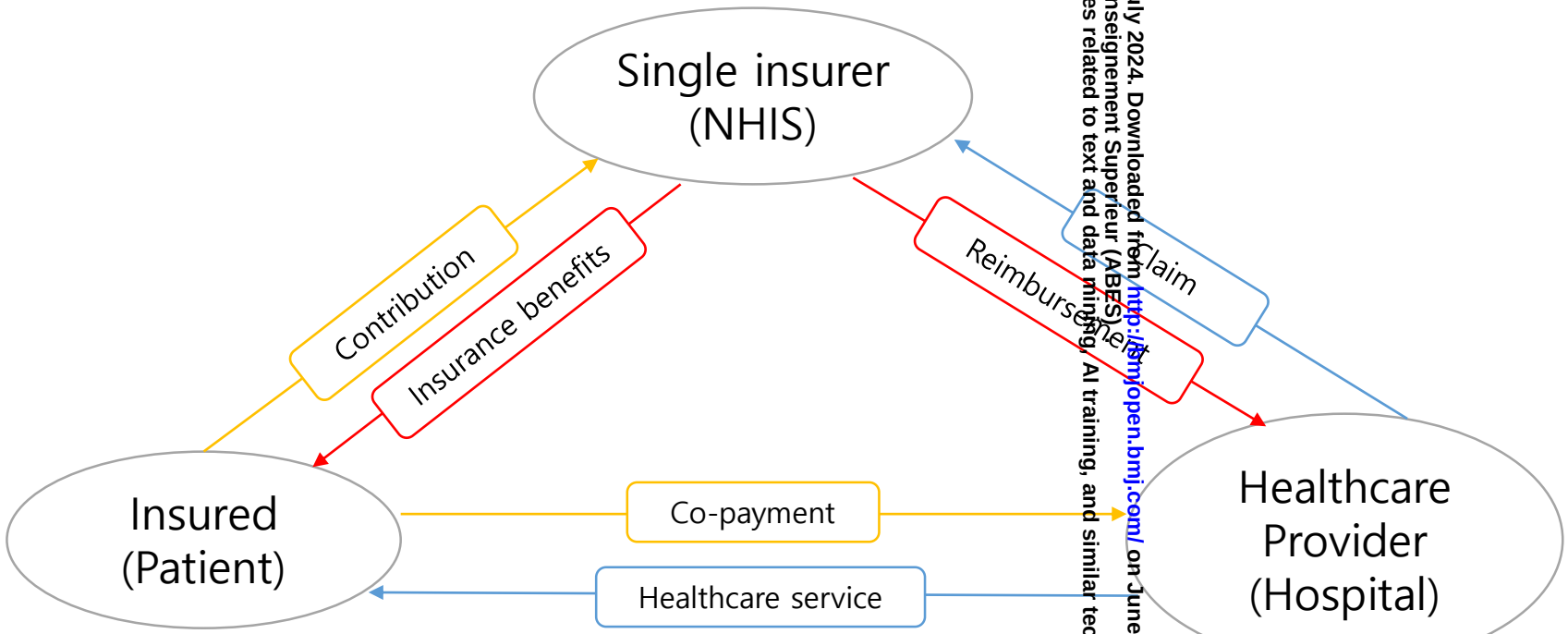
Supplementary 1. Flow diagram of the study population and benefit-cost factors

Supplementary 2. Type of costs, cost estimation formula and data source

Type of costs	Cost estimation formula & data source
Direct costs	C1 + C2 + C3 + C4
Direct medical costs	C1
Total medical expense in hospitalization (C1)	Individual medical treatment bill receipt (real data) ① consultation fee ② admission fee ③ medication fee (including medication / injection / anesthesia / WB and blood product) ④ treatment and surgery fee ⑤ medical examintaion fee (including inspection / medical imaging / CT / MRI /PET / Ultrasonography) ⑥ therapeutic materials ⑦ the others (prosthetics, orthodontics / rehab and physiotherapy / psycotherapy)
Direct non-medical costs	C2 + C3 + C4
Family caregiver transportation fare in hospitalization (C2)	$19* LOS 2017 Korea health panel study / 2019 Annual report on the consumer price index (referenced data), LOS : real data
Paid care cost in hospitalization (C3)	$53 * LOS The Social Cost of Informal Nursing Care and its Policy Implications for Integrated Nursing and Care Services (2021)(referenced data), LOS : real data
Doctor's labor cost (C4)	
Resident's labor costs (day shift)	2017 resident training environment evaluation survey results
Salary after tax	$26,760 ~ $35,935, average salary after tax : $30,851
Resident's labor costs per doctor	$37,350 ~ $52,669 Estimating using 4 Major SIS's (Social Insurance Schemes; national pension, health insurance, employment insurance, workers' compensation insurance) and tax (income tax and resident tax)
Resident's average labor costs per doctor	$44,180
Number of inpatient per day per doctor	17
Number of inpatients per year per doctor	17*365=6,205
Total number of resident assigned to the NHG group	Total patient days of NHG group (45,196) / Number of inpatients per year per doctor (6,205) =7.3
Total Resident's labor costs in the in the NHG group	$44,180 * 7.3 = $322,514
Resident's labor costs per patient per day in the NHG group	$322,514 / 45,196 = $7
Resident's labor costs per patient in the NHG group	$7 * LOS per admission
Resident's labor costs (night shift)	2017 resident training environment evaluation survey results
Number of inpatient per day per doctor	41.8
Number of inpatients per year per doctor	41.8*365=15,257
Total number of resident assigned to the NHG group	Total patient days of NHG group (45,196) / Number of inpatients per year per doctor (15,257) =2.96 (3)

Type of costs	Cost estimation formula & data source
Total Resident's labor costs in the in the NHG group	$44,180 * 3 = $132,540
Resident's labor costs per patient per day in the NHG group	$132,540 / 45,196 = $3
Resident's labor costs per patient in the NHG group	$3 * LOS per admission
Specialist's labor costs (day shift)	2017 Specialist salary evaluation survey results
Specialist's average labor costs per doctor	average $115,452
Number of average inpatient per day per doctor	5
Number of inpatients per year per doctor	5*365=1825
Total number of specialist assigned to the NHG group	Total patient days of the control group (45,196)/1825 =45196/1825=24.7
Total specialist's labor costs in the NHG group	$115,452 *24.7= $2,851,664
Specialist's labor costs per patient per day in the NHG group	$ 2,851,664/ 45196 (total patient days) = $63
Specialist's labor costs per patient in the NHG group	$63 * LOS per admission
Hospitalist's labor costs (day shift)	A study on the implementation and the evaluation of Korean hospitalist system to improve the quality of hospitalization (phase 2)(2018)
Hospitalist's labor costs per doctor	average $115452
Total number of hospitalist assigned to the HG group	4
Hospitalist's labor costs per patient per day of AMU in the HG group	$461,808 / 7216 (Total AMU-LOS) = $64
Doctor's labor cost per patient in the HG group	
1) No referral patients	($64 +$3)* AMU-LOS
2) Referral patients	($64 +$3)* AMU-LOS+ ($63+ $7 + $3)* referral medical ward-LOS
Indirect Costs	C5 + C6 + C7 + C8
Family caregiver productivity loss according to LOS (C5)	$106 * LOS 2017 Survey report on labor conditions by employment type (referenced data), LOS (real data)
Patient productivity loss according to ED-LOS (C6)	Hourly wage * ED-LOS * labor force participation rate (age, gender) 2017 Survey report on labor conditions by employment type (referenced data) 2017 Annual report on the the economically active population survey (referenced data), ED-LOS (real data)
Patient productivity loss according to LOS (C7)	Daily wage * LOS * labor force participation rate (age, gender) 2017 Survey report on labor conditions by employment type (referenced data) 2017 Annual report on the the economically active population survey (referenced data)
Patient productivity loss according to IHM (C8)	Annual wage * deceased patients' expected LYGs * labor force participation rate (age, gender) Statistics Korea. LIFE TABLES FOR KOREA, 2017 (referenced data) 2017 Survey report on labor conditions by employment type (referenced data) 2017 Annual report on the the economically active population survey (referenced data) In hospital mortality (real data)

HG, hospitalist group; NHG, non-hospitalist group; AMU, acute medical unit; LOS, length of hospital stay; ED, emergency department; Cost unit: USD ($1= 1307.9 KRW, year: 2023)



Supplementary 3. Governance of National Health Insurance in South Korea

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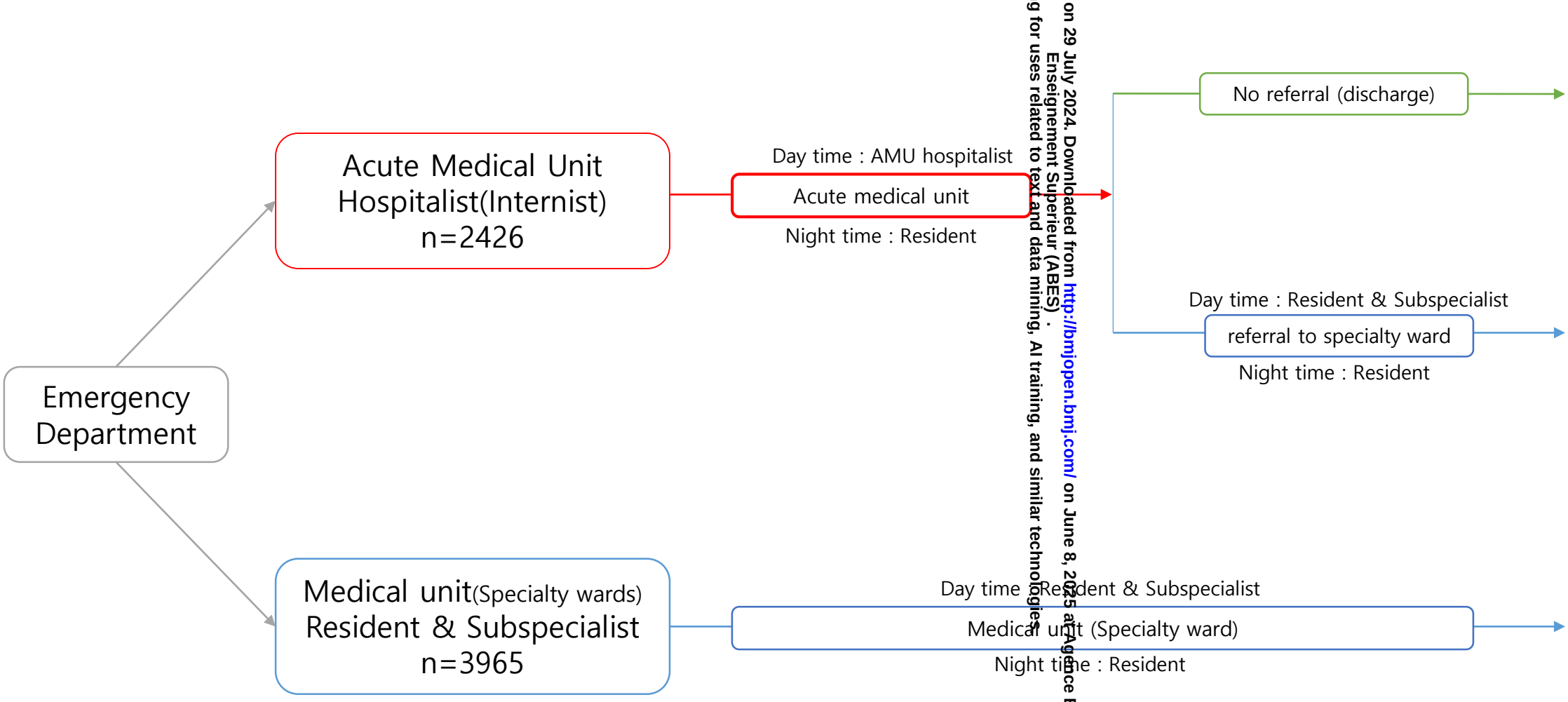


Supplementary 4. Doctor labor cost estimation by patients flow and timeline

Supplementary 5. Cost analysis for urgent and non-urgent cases treated by hospitalists or non-hospitalists (N=639)

	KTAS 1-3: More Urgent (N=5556)			KTAS 4-5: Less Urgent (N=835)		
Cost per patient admission (USD)	**HG (n=2035)**	**NHG (n=3521)**	***P* value**	**HG (n=391)**	**NHG (n=444)**	***P* value**
Total costs	20334±90283	29074±106747	0.002	21801±94897	14269±54923	0.155
Direct costs	5655±8094	6794±8918	0.000	5205±7510	5931±7013	0.150
Direct medical costs	4138±6531	5136±7428	0.000	3747±6363	4371±5666	0.135
Consultation fee	255±228	272±239	0.009	232±183	247±229	0.319
Admission fee	900±1754	1184±1726	0.000	813±1046	1031±1434	0.013
Medication fee	917±2027	901±2321	0.791	850±3570	796±2349	0.794
Treatment and surgery fee	273±1120	454±1797	0.000	227±932	263±884	0.564
Medical examination fee	1288±1684	1585±1704	0.000	1172±1309	1402±1430	0.016
Therapeutic materials	310±896	563±1498	0.000	272±686	469±1292	0.007
Others	193±588	178±475	0.275	181±634	163±397	0.619
Direct non-medical costs	1517±1744	1658±1803	0.005	1458±1363	1560±1649	0.335
Family caregiver transportation fare in hospitalization	199±226	215±234	0.014	191±176	202±214	0.433
Paid care cost in hospitalization	559±634	604±656	0.014	538±496	568±600	0.433
Doctor's labor cost	759±883	840±913	0.001	729±691	790±835	0.255
Indirect costs	14679±88509	22280±105035	0.006	16595±93852	8338±53705	0.114
Patient productivity loss according to LOS	567±815	542±758	0.254	525±576	600±994	0.189
Family caregiver productivity loss according to LOS	1131±1284	1222±1328	0.014	1088±1003	1149±1215	0.433
Patient productivity loss according to ED-LOS	77±75	86±91	0.000	72±73	86±87	0.015
Patient productivity loss according to IHM	12904±88065	20430±104737	0.006	14910±93772	6503±53499	0.107

Data are presented as mean ± standard deviation. HG, hospitalist group; NHG, non-hospitalist group; ED-LOS, emergency department length of stay; LOS, length of hospital stay; IHM, in hospital mortality; KTAS, Korean Triage and Acuity Scale; Cost unit: USD (U.S. Dollar), ($1=1307.9 KRW, year: 2023)

Supplementary 6. Cost analysis for patients with different comorbidity severities treated by hospitalists or non-hospitalists (N=6391)

	ACCI: 0-2 (N=1747)			ACCI: 3 (N=1169)		
Cost per patient admission (USD)	**HG (n=729)**	**NHG (n=1018)**	***P* value**	**HG (n=436)**	**NHG (n=733)**	***P* value**
Total costs	16700±97346	29640±141104	0.033	24948±111135	34965±117962	0.152
Direct costs	4079±5180	5430±8851	0.000	4945±6561	6614±8410	0.000
Direct medical costs	2955±4186	4130±7616	0.000	3545±5099	5006±6938	0.000
Consultation fee	207±163	225±216	0.065	227±162	259±218	0.007
Admission fee	612±794	852±1301	0.000	806±1855	1191±1860	0.001
Medication fee	669±1650	792±2939	0.308	822±2196	868±1975	0.712
Treatment and surgery fee	188±713	350±2163	0.053	191±481	457±1543	0.000
Medical examination fee	968±1143	1312±1586	0.000	1107±1243	1559±1672	0.000
Therapeutic materials	226±613	495±1361	0.000	231±442	512±1170	0.000
Others	85±150	105±198	0.023	163±460	160±395	0.905
Direct non-medical costs	1123±1134	1300±1506	0.008	1399±1568	1608±1749	0.041
Family caregiver transportation fare in hospitalization	148±147	168±195	0.017	184±203	208±227	0.065
Paid care cost in hospitalization	416±412	473±548	0.017	517±571	585±637	0.065
Doctor's labor cost	559±575	658±763	0.003	699±794	814±885	0.026
Indirect costs	12621±96482	24210±139010	0.052	20003±109606	28351±116657	0.227
Patient productivity loss according to LOS	590±683	686±1006	0.026	601±814	585±864	0.749
Family caregiver productivity loss according to LOS	842±835	958±1110	0.017	1046±1155	1184±1288	0.065
Patient productivity loss according to ED-LOS	96±86	120±108	0.000	77±71	92±108	0.011
Patient productivity loss according to IHM	11093±96269	22446±138553	0.057	18280±109064	26491±116420	0.233

Supplementary 5. Cost analysis for patients with different comorbidity severities treated by hospitalists or non-hospitalists (N=6391)

	ACCI: 4 (N=1445)			ACCI: ≥5 (N=2030)		
Cost per patient admission (USD)	**HG (n=502)**	**NHG (n=943)**	***P* value**	**HG (n=759)**	**NHG (n=1271)**	***P* value**
Total costs	14346±46751	22545±67961	0.016	25890±93774	24894±72473	0.789
Direct costs	5315±6670	6754±7792	0.000	7569±10891	7718±9325	0.745
Direct medical costs	3833±5553	5079±6432	0.000	5614±8912	5791±7629	0.635
Consultation fee	247±165	270±202	0.025	311±304	310±279	0.939
Admission fee	879±1158	1222±1657	0.000	1200±2277	1364±1865	0.078
Medication fee	926±3272	874±2016	0.709	1171±2236	991±2157	0.073
Treatment and surgery fee	168±372	398±1248	0.000	448±1747	509±1718	0.437
Medical examination fee	1224±1311	1603±1637	0.000	1682±2223	1742±1753	0.504
Therapeutic materials	250±583	561±1586	0.000	458±1290	615±1632	0.024
Others	138±279	151±310	0.428	345±951	260±690	0.021
Direct non-medical costs	1482±1320	1675±1606	0.021	1956±2229	1927±2071	0.771
Family caregiver transportation fare in hospitalization	195±171	217±208	0.038	256±289	250±268	0.643
Paid care cost in hospitalization	546±480	610±585	0.038	718±811	702±754	0.643
Doctor's labor cost	741±668	848±813	0.012	982±1129	976±1049	0.902
Indirect costs	9031±44942	15791±65530	0.039	18321±91272	17176±71183	0.753
Patient productivity loss according to LOS	418±605	413±467	0.863	602±932	518±711	0.023
Family caregiver productivity loss according to LOS	1106±972	1234±1183	0.038	1453±1642	1420±1526	0.643
Patient productivity loss according to ED-LOS	54±50	63±63	0.010	70±74	72±70	0.643
Patient productivity loss according to IHM	7452±44743	14081±65244	0.042	16195±90754	15167±71041	0.776

Data are presented as mean ± standard deviation. HG, hospitalist group; NHG, non-hospitalist group; ED-LOS, emergency department length of stay; LOS,

length of hospital stay; IHM, in hospital mortality; ACCI, Age-adjusted Charlson Comorbidity Index; Cost unit: USD (U.S. Dollar), ($1=1307.9 KRW, year: 2023)

Supplementary 7. Cost analysis according to major diseases between hospitalist and non-hospitalist groups (N=6391)

	Malignant neoplasms (N=1735)			Diseases of the circulatory system (N=600)		
Cost per patient admission (USD)	**HG (n=845)**	**NHG (n=890)**	***P* value**	**HG (n=48)**	**NHG (n=552)**	***P* value**
Total costs	37059±128241	63186±163463	0.000	21568±84888	10963±37071	0.100
Direct costs	6745±7389	8040±8268	0.001	5861±6678	6706±10303	0.577
Direct medical costs	4971±6044	6076±6910	0.000	4475±5856	5511±9028	0.435
Consultation fee	279±208	307±220	0.007	233±140	210±200	0.438
Admission fee	1066±1330	1355±1482	0.000	801±838	865±1514	0.772
Medication fee	1288±2927	1582±2985	0.039	805±1995	415±1808	0.156
Treatment and surgery fee	231±566	374±1261	0.003	382±1522	532±2658	0.700
Medical examination fee	1437±1524	1704±1524	0.001	1431±1314	1700±1771	0.303
Therapeutic materials	369±767	443±773	0.045	690±2848	1672±3114	0.035
Others	300±846	311±816	0.780	134±190	117±308	0.710
Direct non-medical costs	1774±1573	1964±1690	0.007	1386±1089	1195±1550	0.404
Family caregiver transportation fare in hospitalization	232±204	255±219	0.028	182±141	155±201	0.357
Paid care cost in hospitalization	652±573	715±615	0.028	512±397	435±564	0.357
Doctor's labor cost	890±796	995±856	0.009	692±550	605±785	0.453
Indirect costs	30314±126770	55146±163122	0.000	15706±84189	4257±35265	0.066
Patient productivity loss according to LOS	703±873	721±834	0.674	531±683	359±651	0.082
Family caregiver productivity loss according to LOS	1320±1159	1447±1245	0.028	1036±804	881±1142	0.357
Patient productivity loss according to ED-LOS	84±85	109±121	0.000	74±60	64±63	0.283
Patient productivity loss according to IHM	28206±126390	52868±163024	0.000	14065±84010	2953±35224	0.074

Supplementary 5. Costs analysis according to major diseases between hospitalist and non-hospitalist groups (N=6291)

	Diseases of the respiratory system (N=1141)			Diseases of the digestive system (N=865)		
Cost per patient admission (USD)	**HG (n=266)**	**NHG (n=875)**	***P* value**	**HG (n=441)**	**NHG (n=424)**	***P* value**
Total costs	12369±28381	18568±58264	0.904	10408±66247	19732±94288	0.092
Direct costs	6392±14038	6756±7626	0.585	3994±5522	5143±6628	0.006
Direct medical costs	4622±11505	4896±6064	0.610	2942±4606	3932±5768	0.005
Consultation fee	274±324	280±211	0.713	210±151	229±166	0.072
Admission fee	1257±3766	1444±1942	0.283	560±807	781±1151	0.001
Medication fee	649±1527	655±1082	0.947	546±1361	717±1612	0.092
Treatment and surgery fee	477±2303	480±1181	0.982	296±1022	412±1469	0.176
Medical examination fee	1508±2834	1548±1650	0.773	947±1200	1250±1407	0.001
Therapeutic materials	275±1149	321±864	0.486	302±596	465±1079	0.006
Others	182±495	169±324	0.609	82±303	79±131	0.866
Direct non-medical costs	1770±2731	1860±1779	0.529	1052±1103	1211±1102	0.035
Family caregiver transportation fare in hospitalization	232±354	241±231	0.617	139±143	157±143	0.060
Paid care cost in hospitalization	651±994	677±648	0.617	389±401	441±401	0.060
Doctor's labor cost	887±1384	942±901	0.450	524±559	613±558	0.020
Indirect costs	5977±21125	11812±56671	0.100	6414±63518	14589±92439	0.129
Patient productivity loss according to LOS	495±617	539±589	0.292	438±600	425±475	0.728
Family caregiver productivity loss according to LOS	1318±2011	13705±1311	0.617	788±812	892±812	0.060
Patient productivity loss according to ED-LOS	61±55	67±61	0.176	78±75	109±102	0.000
Patient productivity loss according to IHM	4103±20697	9835±56509	0.105	5110±62720	13163±92261	0.132

Supplementary 5. Costs analysis according to major diseases between hospitalist and non-hospitalist groups (N=6391)

	Diseases of the genitourinary system (N=577)			Symptoms, signs and abnormal clinical and laboratory findings (N=329)		
Cost per patient admission (USD)	**HG (n=202)**	**NHG (n=375)**	***P* value**	**HG (n=162)**	**NHG (n=167)**	***P* value**
Total costs	14018±80863	11979±59324	0.730	6724±9524	10762±50267	0.316
Direct costs	4586±6045	5240±5305	0.179	4513±4763	4322±4123	0.698
Direct medical costs	3232±4721	3819±4212	0.127	3324±3901	3358±3469	0.935
Consultation fee	240±216	265±194	0.159	215±147	188±113	0.061
Admission fee	709±1072	909±1247	0.054	667±1029	664±897	0.978
Medication fee	487±924	505±688	0.797	412±873	272±819	0.133
Treatment and surgery fee	251±867	398±962	0.069	191±843	144±561	0.555
Medical examination fee	1209±1429	1349±1163	0.206	1425±1115	1576±1247	0.249
Therapeutic materials	211±740	263±668	0.391	287±594	443±687	0.027
Others	124±341	129±216	0.833	127±364	69±88	0.049
Direct non-medical costs	1354±1393	1422±1218	0.548	1188±1020	965±828	0.029
Family caregiver transportation fare in hospitalization	178±180	184±158	0.679	157±132	125±107	0.017
Paid care cost in hospitalization	501±506	518±443	0.679	440±372	351±302	0.017
Doctor's labor cost	675±706	720±617	0.433	591±516	488±419	0.048
Indirect costs	9432±80267	6739±59151	0.647	2211±7619	6440±49512	0.283
Patient productivity loss according to LOS	390±433	398±401	0.827	432±518	315±339	0.015
Family caregiver productivity loss according to LOS	1013±1025	1048±898	0.679	891±753	711±610	0.017
Patient productivity loss according to ED-LOS	63±56	72±60	0.061	74±69	65±57	0.201
Patient productivity loss according to IHM	7967±80156	5221±59220	0.640	814±7629	5349±49507	0.250

Supplementary 5. Costs analysis according to major diseases between hospitalist and non-hospitalist groups (N=6391)

	Certain infectious and parasitic diseases (N=290)			Endocrine, nutritional and metabolic diseases (N=253)		
Cost per patient admission (USD)	**HG (n=86)**	**NHG (n=204)**	***P* value**	**HG (n=95)**	**NHG (n=158)**	***P* value**
Total costs	5411±4722	22358±91703	0.088	13906±78014	5765±8350	0.194
Direct costs	3883±3635	6816±10268	0.010	4368±7154	4229±6390	0.873
Direct medical costs	2568±2562	5124±8747	0.008	3049±5368	2940±4887	0.868
Consultation fee	215±154	269±267	0.081	247±298	220±190	0.382
Admission fee	692±782	1452±2060	0.001	643±877	772±1342	0.403
Medication fee	430±475	1010±3434	0.120	491±1521	334±739	0.272
Treatment and surgery fee	107±382	414±1780	0.116	278±1157	188±727	0.450
Medical examination fee	874±817	1562±1959	0.002	1052±1331	1154±1493	0.582
Therapeutic materials	132±378	297±706	0.042	201±719	148±388	0.451
Others	118±171	121±171	0.890	138±373	123±337	0.745
Direct non-medical costs	1315±1144	1693±1837	0.078	1320±1893	1289±1562	0.891
Family caregiver transportation fare in hospitalization	173±148	219±238	0.096	174±245	167±202	0.818
Paid care cost in hospitalization	486±416	616±669	0.096	488±688	469±569	0.818
Doctor's labor cost	655±580	857±930	0.063	658±959	653±791	0.963
Indirect costs	1529±1142	15542±85899	0.132	9538±77367	1536±2047	0.194
Patient productivity loss according to LOS	475±390	593±911	0.248	547±1405	495±927	0.722
Family caregiver productivity loss according to LOS	984±842	1247±1353	0.096	987±1393	950±1151	0.818
Patient productivity loss according to ED-LOS	69±59	98±101	0.014	70±67	91±93	0.061
Patient productivity loss according to IHM	0±0	13603±85029	0.139	7933±77324	0±0	0.198

Supplementary 5. Costs analysis according to major diseases between hospitalist and non-hospitalist groups (N=6391)

	Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism (N=177)			Diseases of the musculoskeletal system and connective tissue (N=147)		
Cost per patient admission (USD)	**HG (n=130)**	**NHG (n=47)**	***P* value**	**HG (n=58)**	**NHG (n=89)**	***P* value**
Total costs	12512±56607	65460±236052	0.018	9269±12785	19916±41366	0.059
Direct costs	5347±9271	11120±17718	0.006	6952±10169	9882±15156	0.198
Direct medical costs	4096±7591	8910±15066	0.006	4911±8119	6869±10992	0.246
Consultation fee	216±217	372±408	0.001	318±324	431±582	0.181
Admission fee	815±1308	1497±2129	0.011	1120±1601	1679±3139	0.212
Medication fee	1851±4590	4170±8980	0.026	795±1826	1126±2184	0.340
Treatment and surgery fee	101±385	351±1111	0.027	397±1677	678±2170	0.405
Medical examination fee	877±1456	2081±2924	0.000	1594±2083	2076±2464	0.221
Therapeutic materials	109±322	244±508	0.038	365±1187	555±1404	0.396
Others	126±245	195±323	0.136	322±983	325±575	0.982
Direct non-medical costs	1252±1771	2210±2811	0.008	2041±2220	3013±4370	0.119
Family caregiver transportation fare in hospitalization	165±229	286±364	0.009	267±288	390±566	0.128
Paid care cost in hospitalization	463±644	805±1023	0.009	751±808	1097±1591	0.128
Doctor's labor cost	624±898	1119±1423	0.007	1023±1125	1526±2213	0.112
Indirect costs	7164±54445	54339±225117	0.027	2317±2716	10034±30967	0.061
Patient productivity loss according to LOS	502±864	1085±1937	0.006	724±1176	973±1201	0.218
Family caregiver productivity loss according to LOS	937±1304	1629±2071	0.009	1520±1635	2220±3220	0.128
Patient productivity loss according to ED-LOS	76±62	79±69	0.760	73±72	95±97	0.149
Patient productivity loss according to IHM	5649±53865	51546±222629	0.030	0±0	6747±29316	0.082

Supplementary 5. Costs analysis according to major diseases between hospitalist and non-hospitalist groups (N=6291)

	Others (N=277)		
Cost per patient admission (USD)	**HG (n=93)**	**NHG (n=184)**	***P* value**
Total costs	19377±105815	28223±115873	0.537
Direct costs	6402±6756	7917±12833	0.288
Direct medical costs	4563±5134	5927±10870	0.253
Consultation fee	276±253	326±373	0.238
Admission fee	932±970	1402±2387	0.070
Medication fee	1323±2546	1207±2713	0.732
Treatment and surgery fee	217±673	700±3802	0.226
Medical examination fee	1297±1256	1695±2068	0.090
Therapeutic materials	346±985	419±1140	0.597
Others	172±287	178±302	0.869
Direct non-medical costs	1839±1890	1989±2429	0.601
Family caregiver transportation fare in hospitalization	241±245	258±315	0.646
Paid care cost in hospitalization	676±687	724±884	0.646
Doctor's labor cost	922±959	1007±1230	0.560
Indirect costs	12975±104723	20306±111437	0.598
Patient productivity loss according to LOS	702±847	787±1514	0.612
Family caregiver productivity loss according to LOS	1368±1390	1465±1790	0.646
Patient productivity loss according to ED-LOS	82±104	101±93	0.111
Patient productivity loss according to IHM	10824±104381	17952±110517	0.606

Data are presented as mean ± standard deviation. HG, hospitalist group; NHG, non-hospitalist group; ED-LOS, emergency department length of stay; LOS,

length of hospital stay; IHM, in hospital mortality; Cost unit: USD (U.S. Dollar), ($1=1307.9 KRW, year: 2023)

Supplementary 8. Cost analysis according to age between hospitalist and non-hospitalist groups (N=6391)

	Age < 50yrs (N=1098)			Age : 50-59yrs (N=900)		
Cost per patient admission (USD)	**HG (n=488)**	**NHG (n=610)**	***P* value**	**HG (n=401)**	**NHG (n=499)**	***P* value**
Total costs	34234±156382	46473±187530	0.248	36276±130259	66967±179600	0.004
Direct costs	4965±7242	5876±10166	0.096	5692±6952	7175±9271	0.008
Direct medical costs	3613±5814	4448±8728	0.070	4189±5572	5538±7717	0.003
Consultation fee	228±220	237±232	0.508	246±209	270±262	0.151
Admission fee	771±1372	972±1629	0.030	822±1027	1091±1540	0.003
Medication fee	900±1892	931±2958	0.840	1091±2590	1259±3331	0.407
Treatment and surgery fee	221±1037	402±2643	0.155	216±546	433±1481	0.006
Medical examination fee	1058±1452	1362±1855	0.003	1273±1478	1645±1761	0.001
Therapeutic materials	256±715	410±1298	0.019	314±688	636±1332	0.000
Others	179±619	134±293	0.118	227±706	204±621	0.611
Direct non-medical costs	1352±1593	1428±1674	0.450	1503±1534	1637±1924	0.256
Family caregiver transportation fare in hospitalization	178±206	185±217	0.573	197±199	212±249	0.327
Paid care cost in hospitalization	499±580	520±610	0.573	554±558	596±701	0.327
Doctor's labor cost	675±807	723±848	0.346	752±778	829±974	0.197
Indirect costs	29269±154339	40597±184984	0.279	30584±128853	59792±177975	0.006
Patient productivity loss according to LOS	828±1155	858±1165	0.673	974±1022	1057±1300	0.298
Family caregiver productivity loss according to LOS	1010±1173	1052±1234	0.573	1121±1130	1206±1418	0.327
Patient productivity loss according to ED-LOS	108±90	138±123	0.000	127±102	170±137	0.000
Patient productivity loss according to IHM	27322±153740	38550±184509	0.281	28362±128452	57359±177723	0.006

Supplementary 6. Cost analysis according to age between hospitalist and non-hospitalist groups (N=6391)

	Age : 60-69yrs (N=1275)			Age : 70-79yrs (N=1763)		
Cost per patient admission (USD)	**HG (n=542)**	**NHG (n=733)**	***P* value**	**HG (n=632)**	**NHG (n=1131)**	***P* value**
Total costs	14345±35835	22699±45307	0.000	11861±22867	15868±28322	0.002
Direct costs	5327±6734	7278±9428	0.000	6154±10486	6936±9155	0.103
Direct medical costs	3915±5716	5517±7852	0.000	4500±8559	5232±7548	0.063
Consultation fee	240±162	285±255	0.000	264±230	277±246	0.300
Admission fee	855±1166	1208±1712	0.000	1024±2555	1199±1843	0.098
Medication fee	930±3214	1132±2876	0.239	902±2019	818±1741	0.359
Treatment and surgery fee	226±799	454±1679	0.004	339±1606	504±1840	0.058
Medical examination fee	1210±1355	1663±1737	0.000	1425±2134	1640±1820	0.025
Therapeutic materials	275±661	561±1216	0.000	329±972	608±1712	0.000
Others	179±545	215±574	0.264	218±670	187±499	0.269
Direct non-medical costs	1412±1232	1760±1963	0.000	1654±2069	1703±1915	0.613
Family caregiver transportation fare in hospitalization	185±160	228±254	0.001	217±268	221±248	0.750
Paid care cost in hospitalization	521±449	641±715	0.001	609±753	620±697	0.750
Doctor's labor cost	706±624	891±994	0.000	828±1048	863±970	0.492
Indirect costs	9018±32832	15422±42473	0.004	5707±17578	8932±24592	0.004
Patient productivity loss according to LOS	349±335	421±466	0.002	384±457	399±476	0.526
Family caregiver productivity loss according to LOS	1054±908	1297±1446	0.001	1232±1524	1255±1411	0.750
Patient productivity loss according to ED-LOS	52±45	65±55	0.000	54±48	60±47	0.011
Patient productivity loss according to IHM	7563±32516	13638±42175	0.005	4037±17173	7218±24265	0.004

Supplementary 6. Cost analysis according to age between hospitalist and non-hospitalist groups (N=6391)

	Age ≥ 80yrs (N=1355)		
Cost per patient admission (USD)	**HG (n=363)**	**NHG (n=992)**	***P* value**
Total costs	9310±13469	12453±15958	0.001
Direct costs	5676±6668	6261±5986	0.122
Direct medical costs	4066±5144	4622±4755	0.062
Consultation fee	283±285	268±202	0.298
Admission fee	918±1145	1257±1618	0.000
Medication fee	684±1400	579±929	0.111
Treatment and surgery fee	312±862	352±699	0.377
Medical examination fee	1367±1315	1490±1230	0.109
Therapeutic materials	360±1225	528±1531	0.059
Others	142±284	147±310	0.810
Direct non-medical costs	1610±1801	1639±1452	0.760
Family caregiver transportation fare in hospitalization	211±233	212±188	0.903
Paid care cost in hospitalization	592±655	597±528	0.903
Doctor's labor cost	806±913	830±735	0.627
Indirect costs	3634±9536	6192±13504	0.001
Patient productivity loss according to LOS	364±413	367±352	0.886
Family caregiver productivity loss according to LOS	1199±1326	1207±1069	0.903
Patient productivity loss according to ED-LOS	50±38	56±42	0.026
Patient productivity loss according to IHM	2021±9274	4561±13363	0.001

Data are presented as mean ± standard deviation. HG, hospitalist group; NHG, non-hospitalist group; ED-LOS, emergency department length of stay; LOS,

length of hospital stay; IHM, in hospital mortality; Cost unit: USD (U.S. Dollar), ($1= 1307.9 KRW, year: 2023)

Supplementary 9. Natural log-transformed multivariable regression analysis for medical costs and total costs (N=239)

Variables	Ln(medical costs)			Ln(total costs)		
	coefficient	SE	*P* value	coefficient	SE	*P* value
(constant)	14.601	0.030	0.000	15.641	0.031	0.000
HG (ref= NHG)	-0.355	0.016	0.000	-0.336	0.016	0.000
Female (ref= male)	-0.063	0.012	0.000	-0.064	0.012	0.000
Age	0.001	0.000	0.001	0.004	0.000	0.000
ACCI	0.019	0.003	0.000	0.014	0.003	0.000
KTAS[a] (ref= more urgency)	-0.054	0.018	0.003	-0.024	0.018	0.188
Prior hospitalization history	-0.002	0.001	0.247	0.000	0.001	0.001
LOS	0.034	0.001	0.000	0.033	0.001	0.000
ED-LOS	0.006	0.001	0.000	0.000	0.001	0.000
CPR (ref = No)	-0.170	0.071	0.016	0.042	0.071	0.585
ICU admission (ref = No)	0.711	0.027	0.000	0.684	0.027	0.000
Referral to specialty (ref = No)	0.391	0.017	0.000	0.371	0.017	0.000
Consultation	0.007	0.002	0.000	0.005	0.002	0.006
IHM	0.127	0.024	0.000	0.799	0.024	0.000
Surgical intervention (ref = No)	0.282	0.019	0.000	0.260	0.019	0.000
Major diseases (ref= malignant neoplasms)						
Circulatory system	-0.031	0.025	0.220	0.111	0.025	0.000
Respiratory system	-0.162	0.020	0.000	0.113	0.020	0.000
Digestive system	-0.166	0.021	0.000	0.215	0.021	0.000
Genitourinary system	-0.199	0.024	0.000	0.174	0.024	0.000
Symptoms, signs and abnormal clinical and laboratory findings	-0.068	0.030	0.022	0.117	0.030	0.000
Certain infectious and parasitic diseases	-0.207	0.031	0.000	0.239	0.032	0.000
Endocrine, nutritional and metabolic diseases	-0.330	0.033	0.000	0.238	0.033	0.000
Diseases of the blood and blood- forming organs and certain disorders involving the immune mechanism	-0.062	0.038	0.103	0.138	0.039	0.000
Diseases of the musculoskeletal system and connective tissue	-0.326	0.042	0.000	-0.251	0.042	0.000
Others	-0.200	0.032	0.000	-0.163	0.032	0.000
	Adj- R2 = 0.686, F = 583.730 (p = 0.000)			Adj- R2 = 0.822, F = 1237.748 (p = 0.000)		

HG, hospitalist group; NHG, non-hospitalist group; ACCI, Age-adjusted Charlson Comorbidity Index; KTAS, Korean Triage and Acuity Scale; CPR, Cardio-pulmonary resuscitation; IHM, in-hospital mortality; ICU, intensive care unit; LOS, length of hospital stay; ED-LOS, emergency department length of stay; SE, standard error

"surgical intervention" implies the patient underwent surgery during the hospital stay, not before.

[a]the less urgent group with KTAS = 4–5 was compared to the more urgent group with KTAS = 1–3.

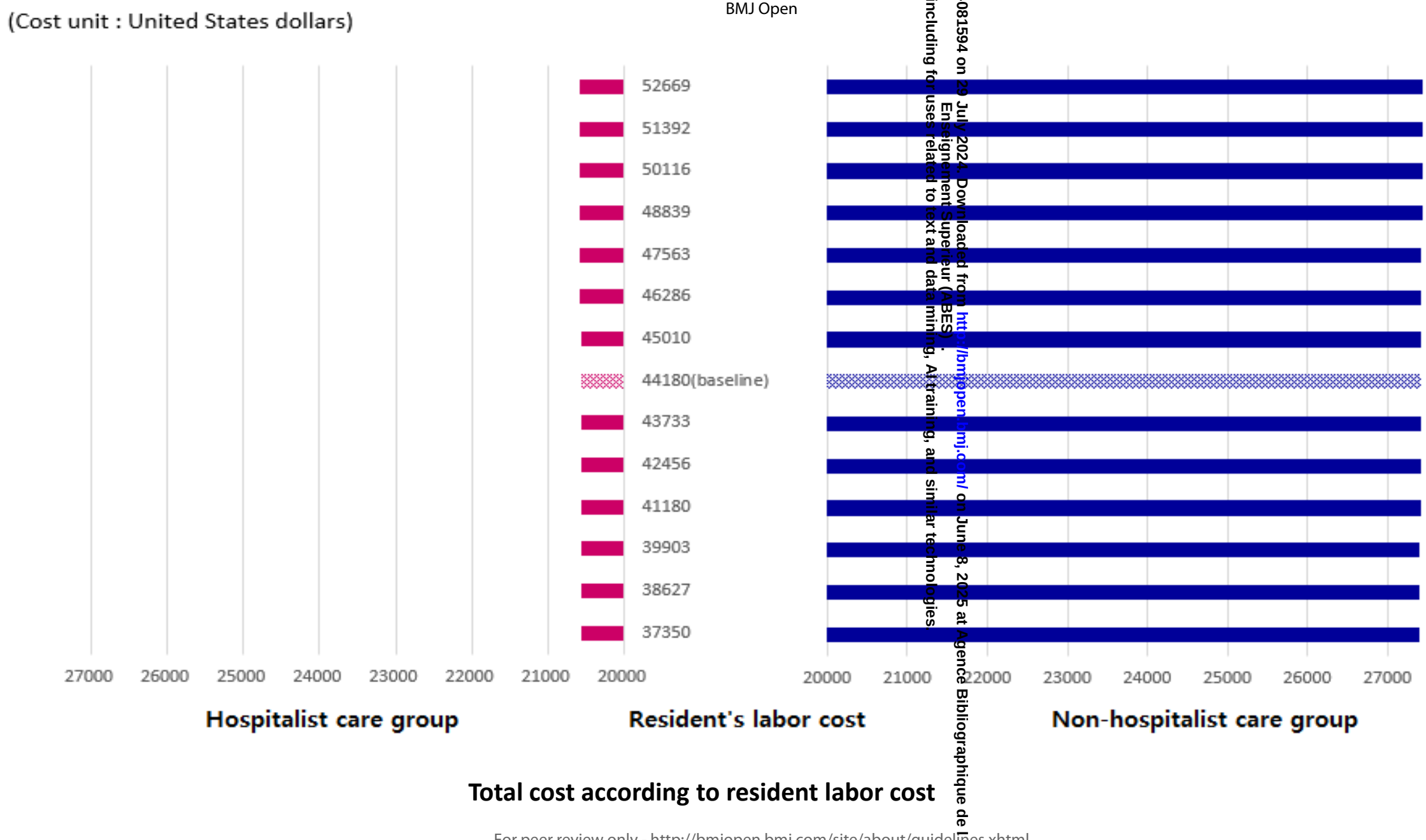
Supplementary 10. Natural log-transformed multivariable regression analysis for direct costs and indirect costs (N=63,991)

Variables	Ln(direct costs)			Ln(indirect costs)		
	coefficient	SE	*P* value	coefficient	SE	*P* value
(constant)	14.946	0.027	0.000	14.582	0.030	0.000
HG (ref= NHG)	-0.336	0.014	0.000	-0.215	0.016	0.000
Female (ref= male)	-0.048	0.011	0.000	-0.026	0.012	0.000
Age	0.001	0.000	0.002	0.009	0.000	0.000
ACCI	0.017	0.003	0.000	0.004	0.003	0.229
KTAS[a] (ref= more urgency)	-0.032	0.016	0.041	-0.009	0.017	0.651
Prior hospitalization history	-0.000	0.001	0.763	0.007	0.001	0.000
LOS	0.038	0.001	0.000	0.044	0.001	0.000
ED-LOS	0.005	0.001	0.000	0.001	0.001	0.000
CPR (ref = No)	-0.186	0.062	0.003	-0.130	0.069	0.004
ICU admission (ref = No)	0.573	0.024	0.000	0.040	0.026	0.127
Referral to specialty (ref = No)	0.400	0.015	0.000	0.294	0.017	0.000
Consultation	0.002	0.001	0.194	0.010	0.002	0.000
IHM	0.063	0.021	0.003	0.119	0.024	0.000
Surgical intervention (ref = No)	0.225	0.017	0.000	0.095	0.019	0.000
Major diseases (ref= malignant neoplasms)						
Circulatory system	-0.055	0.022	0.014	0.238	0.025	0.000
Respiratory system	-0.116	0.018	0.000	0.020	0.020	0.000
Digestive system	-0.163	0.019	0.000	0.215	0.021	0.000
Genitourinary system	-0.150	0.021	0.000	0.035	0.024	0.000
Symptoms, signs and abnormal clinical and laboratory findings	-0.084	0.026	0.001	0.200	0.029	0.000
Certain infectious and parasitic diseases	-0.149	0.028	0.000	0.174	0.031	0.000
Endocrine, nutritional and metabolic diseases	-0.257	0.029	0.000	0.133	0.032	0.000
Diseases of the blood and blood- forming organs and certain disorders involving the immune mechanism	-0.094	0.034	0.005	0.153	0.037	0.000
Diseases of the musculoskeletal system and connective tissue	-0.237	0.037	0.000	-0.133	0.041	0.000
Others	-0.138	0.028	0.000	-0.069	0.031	0.027
	Adj- R2 = 0.726, F = 705.745 (p = 0.000)			Adj- R2 = 0.891, F = 2173.571 (p = 0.000)		

HG, hospitalist group; NHG, non-hospitalist group; ACCI, Age-adjusted Charlson Comorbidity Index; KTAS, Korean Triage and Acuity Scale; CPR, Cardio-pulmonary resuscitation; IHM, in-hospital mortality; ICU, intensive care unit; LOS, length of hospital stay; ED-LOS, emergency department length of stay; SE, standard error

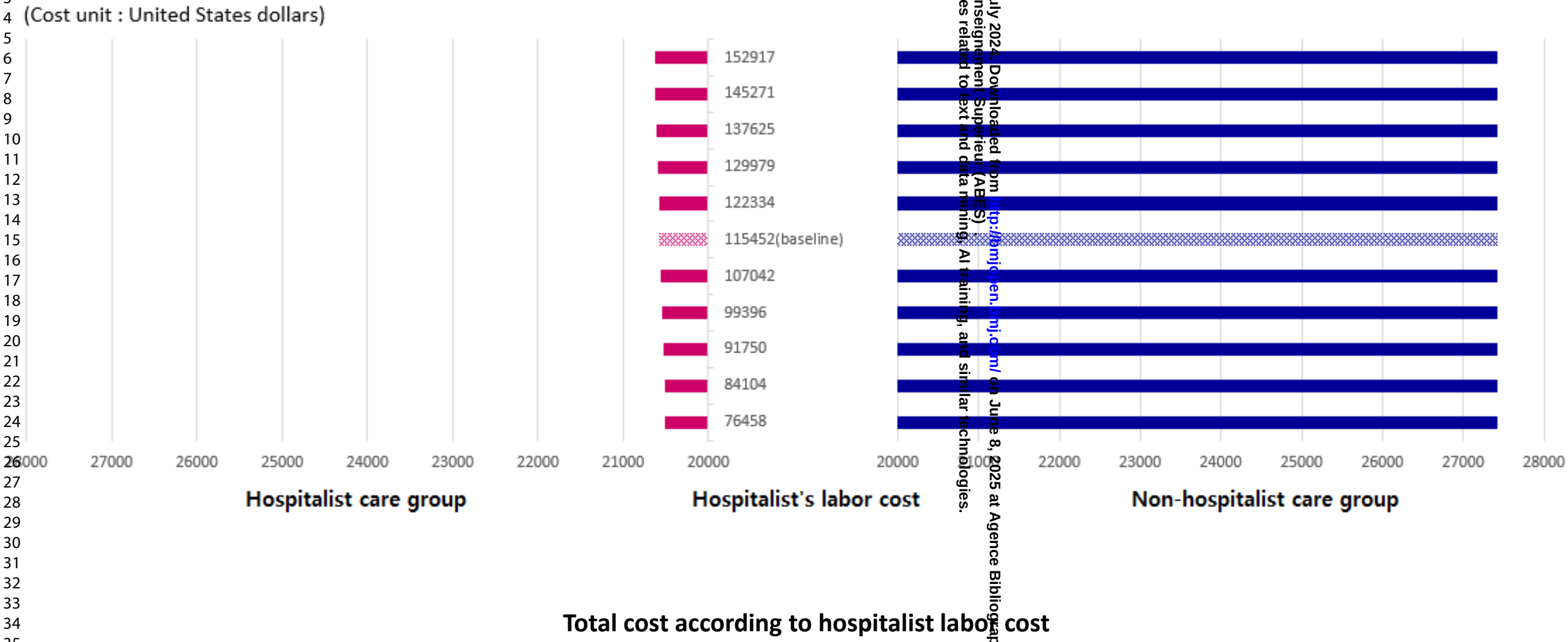
"surgical intervention" implies the patient underwent surgery during the hospital stay, not before.

[a]the less urgent group with KTAS = 4–5 was compared to the more urgent group with KTAS = 1–3.



Supplementary 11. One-way sensitivity analysis for the resident labor cost

Supplementary 12. One-way sensitivity analysis for the specialist labor cost



Supplementary 13. One-way sensitivity analysis for the hospitalist labor cost

Supplementary 14. Two-way sensitivity analysis of net-benefit per patient admission according to doctor labor cost (N=6391)

		Hospitalist labor cost per doctor										
		76458	84104	91750	99396	107042	115452 (baseline)	122334	129979	137625	145271	152917
Resident labor cost per doctor	37350	6905	6893	6880	6867	6855	6841	6830	6817	6804	6792	6779
	38627	6906	6893	6881	6868	6856	6842	6830	6818	6805	6793	6780
	39903	6907	6894	6882	6869	6857	6843	6831	6819	6806	6793	6781
	41180	6908	6895	6883	6870	6857	6843	6832	6820	6807	6794	6782
	42456	6909	6896	6883	6871	6858	6844	6833	6820	6808	6795	6783
	43733	6910	6897	6884	6872	6859	6845	6834	6821	6809	6796	6783
	44180 (baseline)	6910	6897	6885	6872	6859	6846	6834	6822	6809	6796	6784
	45010	6910	6898	6885	6873	6860	6846	6888	6822	6810	6797	6784
	46286	6911	6899	6886	6873	6861	6847	6836	6823	6810	6798	6785
	47563	6912	6899	6887	6874	6862	6848	6836	6824	6811	6799	6786
	48839	6913	6900	6888	6875	6863	6849	6837	6825	6812	6799	6787
	50116	6914	6901	6889	6876	6863	6849	6838	6826	6813	6800	6788
	51392	6915	6902	6889	6877	6864	6850	6839	6826	6814	6801	6789
	52669	6916	6903	6890	6878	6865	6851	6840	6827	6815	6802	6789

Cost unit: USD (US Dollar), ($1 = 1307.9 KRW, year: 2023)

Supplementary 15. Two-way sensitivity analysis of net-benefit per capita according to doctor labor cost (N=6791)

		Hospitalist labor cost per doctor										
		76458	84104	91750	99396	107042	115452 (baseline)	122334	129979	137625	145271	152917
Specialist labor cost per doctor	76458	6829	6816	6803	6791	6778	6764	6753	6741	6728	6715	6703
	84104	6845	6832	6819	6807	6794	6780	6769	6756	6744	6731	6718
	91750	6860	6848	6835	6823	6810	6796	6785	6772	6760	6747	6734
	99396	6876	6864	6851	6839	6826	6812	6801	6788	6841	6763	6750
	107042	6892	6880	6867	6854	6842	6828	6817	6804	6791	6779	6766
	115452 (baseline)	6910	6897	6885	6872	6859	6846	6834	6822	6809	6796	6784
	122334	6924	6912	6899	6886	6874	6860	6848	6836	6823	6811	6798
	129979	6940	6927	6915	6902	6890	6876	6864	6852	6839	6827	6814
	137625	6956	6943	6931	6918	6906	6892	6880	6868	6855	6843	6830
	145271	6972	6959	6947	6934	6921	6908	6896	6884	6871	6858	6846
	152917	6988	6975	6963	6950	6937	6924	6912	6900	6887	6874	6862

Cost unit: USD (U.S. Dollar), ($1= 1307.9 KRW, year: 2023)

CHEERS 2022 Checklist

Topic	No.	Item	Location where item is reported
Title			
	1	Identify the study as an economic evaluation and specify the interventions being compared.	1
Abstract			
	2	Provide a structured summary that highlights context, key methods, results, and alternative analyses.	2
Introduction			
Background and objectives	3	Give the context for the study, the study question, and its practical relevance for decision making in policy or practice.	4
Methods			
Health economic analysis plan	4	Indicate whether a health economic analysis plan was developed and where available.	5
Study population	5	Describe characteristics of the study population (such as age range, demographics, socioeconomic, or clinical characteristics).	5
Setting and location	6	Provide relevant contextual information that may influence findings.	5
Comparators	7	Describe the interventions or strategies being compared and why chosen.	5,6
Perspective	8	State the perspective(s) adopted by the study and why chosen.	4,5
Time horizon	9	State the time horizon for the study and why appropriate.	11
Discount rate	10	Report the discount rate(s) and reason chosen.	11
Selection of outcomes	11	Describe what outcomes were used as the measure(s) of benefit(s) and harm(s).	6
Measurement of outcomes	12	Describe how outcomes used to capture benefit(s) and harm(s) were measured.	6-8
Valuation of outcomes	13	Describe the population and methods used to measure and value outcomes.	6-8
Measurement and valuation of resources and costs	14	Describe how costs were valued.	8-10
Currency, price date, and conversion	15	Report the dates of the estimated resource quantities and unit costs, plus the currency and year of conversion.	8,9,13

Topic	No.	Item	Location where item is reported
Rationale and description of model	16	If modelling is used, describe in detail and why used. Report if the model is publicly available and where it can be accessed.	Not applicable
Analytics and assumptions	17	Describe any methods for analysing or statistically transforming data, any extrapolation methods, and approaches for validating any model used.	11,12
Characterising heterogeneity	18	Describe any methods used for estimating how the results of the study vary for subgroups.	12
Characterising distributional effects	19	Describe how impacts are distributed across different individuals or adjustments made to reflect priority populations.	10-12
Characterising uncertainty	20	Describe methods to characterise any sources of uncertainty in the analysis.	10-12
Approach to engagement with patients and others affected by the study	21	Describe any approaches to engage patients or service recipients, the general public, communities, or stakeholders (such as clinicians or payers) in the design of the study.	12
Results			
Study parameters	22	Report all analytic inputs (such as values, ranges, references) including uncertainty or distributional assumptions.	13-18
Summary of main results	23	Report the mean values for the main categories of costs and outcomes of interest and summarise them in the most appropriate overall measure.	13-18
Effect of uncertainty	24	Describe how uncertainty about analytic judgments, inputs, or projections affect findings. Report the effect of choice of discount rate and time horizon, if applicable.	18
Effect of engagement with patients and others affected by the study	25	Report on any difference patient/service recipient, general public, community, or stakeholder involvement made to the approach or findings of the study	Not applicable
Discussion			
Study findings, limitations, generalisability, and current knowledge	26	Report key findings, limitations, ethical or equity considerations not captured, and how these could affect patients, policy, or practice.	18-22
Other relevant information			
Source of funding	27	Describe how the study was funded and any role of the funder in the identification, design, conduct, and reporting of the analysis	23
Conflicts of interest	28	Report authors conflicts of interest according to journal or International Committee of Medical Journal Editors requirements.	24

From: Husereau D, Drummond M, Augustovski F, et al. Consolidated Health Economic Evaluation Reporting Standards 2022 (CHEERS 2022) Explanation and Elaboration: A Report of the ISPOR CHEERS II Good Practices Task Force. Value Health 2022;25. doi:10.1016/j.jval.2021.10.008