Impact of Hospitalist Care Model on Patient Outcomes in Acute Medical Unit

Hyun Jeong Kim
Seoul National University College of Nursing https://orcid.org/0000-0003-1993-0593
Jinhyun Kim (jinhyun@snu.ac.kr)
https://orcid.org/0000-0001-7141-1606
Jung Hun Ohn
Seoul National University Bundang Hospital
Nak-Hyun Kim
Seoul National University Bundang Hospital

Research article

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Abstract

BACKGROUND: The present study aimed to assess a newly introduced, hospitalist-run, acute medical unit (AMU) model in Korea. The AMU in our institution started in October 2015. Four hospitalists managed patients with acute medical needs that were admitted through the emergency department (ED).

STUDY DESIGN: We conducted a retrospective cohort study of all medical inpatients admitted through the ED from June 1, 2016 to May 31, 2017, at a tertiary care hospital. We evaluated 6391 patients whether the hospitalist care in the AMU improved patient outcomes compared to standard non-hospitalist care.

METHODS: We created multivariate analysis models to compare the clinical outcomes of patients cared for by hospitalists with the outcomes of patients cared for by non-hospitalists.

RESULTS: In the adjusted models, compared to the non-hospitalist group, the AMU hospitalist group had a lower in-hospital mortality (OR: 0.46, P <0.001), a lower intensive care unit (ICU) admission rate (OR: 0.39, P <0 .001), a shorter hospital length of stay (coefficient: -1.349, SE: 0.217; P <0.001), and a shorter ED waiting time (coefficient: -3.021, SE: 0.256; P <0.001). There were no significant differences in the 10-day or 30-day re-admission rates (P = 0.493, P = 0.201; respectively).

CONCLUSIONS: The AMU hospitalist care model was associated with reductions in in-hospital mortality, ICU admission rate, length of hospital stay, and ED waiting time. These findings suggested that this AMU hospitalist care model might be adaptable to other healthcare systems to improve care for patients with acute medical needs.

Background

In recent years, the hospitalist care model in South Korea was developed to improve the quality of inpatient care and to address the reduced number of available medical residents, due to the Resident Act, which limited their work hours to 80 h per week [1]. As of July 2019, about 140 physicians in South Korea work as hospitalists and are in charge of about 2200 beds in 22 tertiary hospitals and 10 general hospitals [1].

A hospitalist is defined as a “dedicated specialist that directly takes comprehensive responsibility for the managed care of inpatients during admission” [2, 3]. The two principles that guide the hospitalist’s role are comprehensiveness and continuity [3, 4]. In the US, hospitalists were effective in improving patient satisfaction and in reducing their length of hospital stays, readmission rates, and medical costs [5]. A hospitalist care model in Korea was introduced to enhance the safety and efficiency of inpatient care, and to eliminate gaps in medical staffing that resulted from improvements in the resident training environment [2].

In contrast to the hospitalist care model in the US, the acute medicine care model developed in the UK was concerned with immediate and early specialist management of adult patients with a wide range of medical conditions that required urgent or emergency care [6]. Patients that could be stabilized, treated, and discharged were efficiently dealt with in the acute medical unit (AMU). When a patient appeared to need a longer hospital stay, they were offered a rapid, appropriate hand-off from the AMU to the specialty ward. The key to this hand-off was close cooperation and mutual respect between the providers of complementary specialties [7].

A census of the Royal College of Physicians reported rapid growth in acute medicine in the UK. They showed a 63% increase in the number of consultants in acute medicine between 2002 and 2007. Previous studies that reported the efficacy of AMUs have described reductions in mortality and lengths of hospital stays [8–10].

The Seoul National University Bundang Hospital adopted both the hospitalist care model and the acute medicine unit model. Our institution established the first hospital medicine center in Korea and opened a hospitalist-run AMU in August 2015. The AMU started with a 20-bed ward, where patients with acute medical needs that were admitted through the emergency department (ED) received appropriate and timely medical care. They were discharged within 72 h after the end of treatment in the AMU, or they were transferred to another special ward for additional care, as required [4]. In 2017, the hospitalist team of our hospital reported the effects of the AMU operation. It reduced the ED waiting time by 40%, and it significantly shortened the length of hospital stay (LOS), from 10 days to 9.1 days [11]. However, no study has thoroughly evaluated its effects on patient outcomes, including inhospital mortality, the intensive care unit (ICU) admission rate, or the re-admission rate. Therefore, this study aimed to evaluate the patient outcomes of an AMU that was operated according to the Korean hospitalist care model and to provide supporting data that might inform the design of the most efficient Korean hospitalist care model.

Methods

AMU setting

The AMU had 28 beds, but started with 20 beds. Medical patients waiting in the ED were randomly admitted to either the AMU or the medical ward, as soon as a bed was available. Patients in the AMU were cared for by four internists that specialized in infection, pulmonary disease, critical care, and endocrinology. Patients admitted to the AMU were rapidly evaluated and treated by internists, who served as hospitalists, with experience in treating patients with acute medical illnesses [11]. This study included all patients with acute medical needs that were admitted to the ED during the daytime, 7 days/week, in the AMU.

On the other hand, non-hospitalist inpatient care was performed by subspecialists and residents in a specialty medical ward. In the specialty medical ward, residents were mainly in charge of inpatient care, under the supervision of an attending physician. The AMU hospitalist care at our institution mainly focused on acute and general care. In contrast, non-hospitalist care in the specialty medical ward was focused on long-term and specialized care. The AMU models of Korea and the UK are compared in Fig. 1 [12].

Study design

This retrospective cohort study employed a secondary analysis of data from clinical records and hospital administrative information in Electronic Medical Record (EMR) of our institution. The local Institutional Review Board approved the waiver of consent and other study procedures.

Subjects

All medical inpatients admitted from the ED between June 1, 2016 and May 31, 2017 were included for the case and control groups. We excluded admissions to the ICU and surgical ward via the ED. A flow diagram of the allocation of the study population is presented in Fig. 2.

Variables

We measured the following outcome variables: in-hospital mortality (IHM), ICU admission, length of hospital stay (LOS), ED waiting time, and unscheduled re-admissions, within 10 days and 30 days. The IHM was defined as the ratio of inpatient deaths to the total number of inpatients. ICU admission was defined as an entry into the ICU.

When a patient was admitted more than once during a single hospital stay, only the features of the first admission were analyzed. The LOS was defined as the duration of a single episode of hospitalization and was calculated by subtracting the date of admission from the date of discharge. The ED waiting time was defined as the time spent waiting in the ED before admission to the AMU or a medical ward. Re-admissions were identified as an unscheduled admission via the ED, due to any cause, within 10 or 30 days after discharge.

We recorded the following clinical variables of the subjects: gender, age, prior hospitalization history, cardiopulmonary resuscitation (CPR) incidence, cause of ICU admission, referral to a specialty, referral to a specialty unit, consultations, operations (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)), the Korean Triage and Acuity Scale (KTAS), the Age-adjusted Charlson Comorbidity Index (ACCI), and the Acute Physiology and Chronic Health Evaluation (APACHE) II score.

The KTAS consisted of five stages: resuscitation, emergency, urgent, less urgent, and non-urgent. This was Korea's first unified emergency patient triage system at the national level. It was developed in accordance with the domestic situation, and it was based on the Canadian triage and acuity scale [13]. The KTAS, which is currently applied in emergency medical centers in Korea, is a national standardized classification tool for evaluating illness severity. It is the only tool commonly available for assessing patients from the pre-hospital phase to the hospital phase. Previous validity testing showed that the higher the severity level, the higher the ICU and general hospital admission rates, the LOS, the number of clinic consultations, the CT scan rate, the emergency intervention rate, and the ED medical expenses. Thus, the KTAS was confirmed as a valid tool that reflected the severity trend, and it is currently used in national and regional emergency medical centers [13]. Accordingly, in this study, we used the KTAS to compare the severity of conditions among patients.

The comorbidity score was calculated with the Charlson Comorbidity Index (CCI). The CCI score is 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]. Additionally, because age was determined to be a significant factor of survival, it was subsequently incorporated into the Charlson comorbidity score to create a single index that accounted for both age and comorbidity; i.e., the ACCI [15]. The ACCI was calculated with additional points added for age (1point was added for each decade over 40 years of age, ranging from 0 to 4). In addition, the clinical comorbidities were translated into ICD codes, which were used as a risk-adjustment tool based on administrative data [16]. Therefore, in this study, we used ICD-coded data and age to calculate the ACCI score.

The APACHE II scoring system has been widely recognized as an ICU prognostic scoring model [17–19]. The APACHE II score utilizes the worst values of 12 physiological variables, including: blood pressure, heart rate, body temperature, oxygenation, Glasgow Coma Score (GCS) during the first 24 h after ICU admission, an evaluation of the patient's chronic health issues, age, and the type of ICU admission [20]. The APACHE II score was shown to be an accurate measurement of the severity of a patient's disease, and it was strongly correlated with outcome among patients in critical conditions [17]. This score (range 0 to 71) was closely correlated with the risk of hospital death [18]. Consequently, we used the APACHE II score to compare the disease severity among ICU admissions.

Statistical Analysis

Categorical variables are reported as percentages, and continuous variables are reported as the mean ± standard deviation (SD). Groups were compared with Pearson's chi-square test or the t-test, as appropriate. ACCI, the LOS, and the ED waiting time are expressed as the median and interquartile range (IQR). For these variables, groups were compared with the Mann-Whitney *U* test, due to their skewed data distributions. We performed subgroup analyses according to the severity of the patient's condition (based on the KTAS score), the degree of comorbidity (based on the ACCI), and the major disease category (based on the ICD-10).

We identified disease codes for the 10 most frequent diseases in the cohort. The remaining diseases were aggregated into a single category designated as "others." We then included these disease codes as dummy variables in the regression models to determine the extent to which they affected the outcome. The main analyses focused on the five outcome measures for the case and control groups. Logistic regression model (for IHM, ICU admission, and all-cause unscheduled re-admissions as binary outcomes) and linear regression model (for LOS and ED waiting time as continuous variables) were used to adjust for age, gender, prior hospitalization, KTAS, ACCI, CPR incidence, referral to a specialty, operation, consultation, major disease. Using the estimates from the regression models, we presented differences between the hospitalist group and the non-hospitalist groups in the IHM rate, ICU admission rate, all-cause unscheduled re-admission rate, LOS, and ED waiting time.

Results

Baseline characteristics

Among the 6391 patients with data available for analysis, 2426 received hospitalist care, and 3965 received non-hospitalist care. The clinical baseline features and outcomes of all patients are shown in Table 1. There were no differences in gender ($P = 0.120$), the number of prior hospitalizations ($P = 0.480$), or the CPR incidence ($P = 0.244$) between the hospitalist and non-hospitalist groups. Compared to the hospitalist group, the non-hospitalist group was older (63.24 ± 16.20 vs. 67.38 ± 16.52 years, $P < 0.001$) and had a higher proportion of individuals over 80 years old (15% vs. 25%, $P < 0.001$), a higher proportion of individuals that underwent operations (11.6% vs. 14.1%, $P = 0.004$), and a higher frequency of consultations (3.50 ± 6.18 vs. 3.99 ± 7.02, $P = 0.004$). Based on the KTAS, the hospitalist group had a higher proportion of patients that required urgent care (KTAS = 3, 70.0%) compared to the non-hospitalist group (63.3%). Moreover, the distributions of patients with KTAS = 2 (13.4% vs. 23.7%, respectively) and KTAS = 4 (15.1% vs. 10.2%, respectively) were different between the two groups ($P < 0.001$ for all). The most common underlying disease in the hospitalist and non-hospitalist groups was malignant neoplasm (34.8% and 22.4%, respectively). The distribution of major diseases was significantly different between groups ($P < 0.001$), but the ACCI scores were not significantly different between groups (median [IQR]: 4 [2–5] vs. 4 [2–5], $P < 0.055$).

Compared to the non-hospitalist group, the hospitalist group had lower rates of IHM (4.8% vs. 9.1%, $P < 0.001$) and ICU admissions (3.9% vs. 8.7%, $P < 0.001$). Among the patients admitted to the ICU, the hospitalist group displayed greater disease severity than the non-hospitalist group (APACHE II scores: 25.20 ± 10.62 vs. 21.26 ± 12.03, $P = 0.004$). The hospitalist group had shorter LOS (median [IQR]: 7 [4–12] vs. 8 [5–13] days, $P < 0.001$) and shorter ED waiting times (median [IQR]: 8.4 [6.1–12.8] vs. 10.2 [6.7–19] h, $P < 0.001$) than the non-hospitalist group. However, there were no significant differences between the two groups in the re-admission rates within 10 or 30 days ($P = 0.507$ and $P = 0.248$, respectively).

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

Characteristics	**Hospitalist (n = 2426)**	**Non-hospitalist (n = 3965)**	***p***
Gender			
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
The 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)	

Data are presented as the mean ± standard deviation, the number (%), or the median (IQR), as indicated.

IQR = interquartile range, CPR = cardiopulmonary resuscitation, ICU = intensive care unit, APACHE = Acute Physiology and Chronic Health Evaluation, ED = emergency department, Operation = case during hospital stay, not before

Characteristics	Hospitalist (n = 2426)	Non-hospitalist (n = 3965)	*p*
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)	
Operation	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
The 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)	

Data are presented as the mean ± standard deviation, the number (%), or the median (IQR), as indicated.

IQR = interquartile range, CPR = cardiopulmonary resuscitation, ICU = intensive care unit, APACHE = Acute Physiology and Chronic Health Evaluation, ED = emergency department, Operation = case during hospital stay, not before

Characteristics	Hospitalist (n = 2426)	Non-hospitalist (n = 3965)	*p*
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 operation	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	10.56 ± 11.68	11.40 ± 12.36	
Median (IQR)	7 (4–12)	8 (5–13)	0.007
ED waiting time	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, the number (%), or the median (IQR), as indicated.

IQR = interquartile range, CPR = cardiopulmonary resuscitation, ICU = intensive care unit, APACHE = Acute Physiology and Chronic Health Evaluation, ED = emergency department, Operation = case during hospital stay, not before

Subgroup analysis, according to KTAS, comorbidity severity, and major disease

We performed subgroup analyses of patients stratified by KTAS and ACCI scores to determine differences between the two groups (Tables 2 and 3, respectively). Among the more urgent cases, the hospitalist group showed lower rates of IHM (4.8% vs. 9.8%, $P < 0.001$) and ICU admission (4.0% vs. 9.1%, $P < 0.001$), compared to the non-hospitalist group.

Among the more urgent cases, patients in the hospitalist group had shorter LOS (median [IQR]: 7 [4–12] vs. 8 [5–13] days, $P = 0.014$) and shorter ED waiting times (median [IQR]: 8.4 [6.1–13.1] vs. 10.3 [6.8–19.1] h, $P < 0.001$) compared to the non-hospitalist group. Among the less urgent cases, the hospitalist group had shorter ED waiting times (median [IQR], 7.8 [5.9–11.0] vs. 8.9 [6.2–18.4] h, $P < 0.001$) than the non-hospitalist group. However, other variables were not significantly different between groups.

In the moderate-to-high comorbidity groups (ACCI = 3, 4, and 5 points), IHM was significantly lower in the hospitalist group than in the non-hospitalist groups ($P = 0.009$, $P < 0.001$, $P = 0.002$; respectively). In the low-to-moderate comorbidity groups (ACCI = 2, 3, and 4 points), ICU admission was significantly lower in the hospitalist groups than in the non-hospitalist group ($P < 0.001$, $P < 0.001$, $P < 0.001$; respectively). In all ACCI groups, the ED waiting times were significantly shorter in the hospitalist group than in the non-hospitalist group.

We performed another analysis of subgroups stratified by the major disease to determine whether the two groups showed differences in IHM (data not shown; additional file 1). Among patients with malignant neoplasms, infectious diseases, and diseases involving the respiratory system, digestive system, musculoskeletal system, and connective tissue, IHM was significantly lower in the hospitalist group than in the non-hospitalist group.

Table 2

Analysis of variables for urgent and non-urgent cases treated by a hospitalist or non-hospitalist (N = 6391)

	KTAS 1–3: More Urgent (N = 5556)			KTAS 4–5: Less Urgent (N = 835)		
Variable	HG (n = 2035)	NHG (n = 3521)	*p*	HG (n = 391)	NHG (n = 444)	*p*
ACCI	3.87 ± 2.63	3.83 ± 2.17		3.56 ± 2.66	3.23 ± 2.28	
Median (IQR)	4[2–5]	4[3–5]	0.037	3[2–5]	3[2–5]	0.236
CPR incidence	12 (0.6)	35 (1.0)	0.113	3 (0.8)	0 (0.0)	0.064
IHM	98 (4.8)	345 (9.8)	< 0.001	19 (4.9)	16 (3.6)	0.366
ICU admission	81 (4.0)	319 (9.1)	< 0.001	14 (3.6)	24 (5.4)	0.207
Cause of ICU admission (n = 438)						
Close monitoring after procedure or operation	44 (54.3)	202 (63.3)	0.040	11 (78.6)	21 (87.5)	0.580
Respiratory failure or insufficiency	21 (25.9)	77 (24.1)		2 (14.3)	1 (4.2)	
Septic shock	6 (7.4)	16 (5.0)		1 (7.1)	1 (4.2)	
Cardiovascular failure or insufficiency	7 (8.6)	11 (3.4)		0 (0.0)	1 (4.2)	
Metabolic/Renal failure	0 (0.0)	8 (2.5)		0 (0.0)	0 (0.0)	
GI bleeding	3 (3.7)	2 (0.6)		0 (0.0)	0 (0.0)	
Neurogenic dysfunction	0 (0.0)	3 (0.9)		0 (0.0)	0 (0.0)	
APACHE II score of ICU admission (n = 438)	25.15 ± 10.62	21.65 ± 12.11	0.018	25.50 ± 11.00	16.17 ± 9.78	0.010
LOS	10.63 ± 12.06	11.47 ± 12.48		10.22 ± 9.42	10.80 ± 11.41	
Median (IQR)	7 (4–12)	8 (5–13)	0.014	7 (5–12)	7 (5–12)	0.433
ED waiting time	11.38 ± 8.56	13.87 ± 10.16		10.54 ± 8.09	12.71 ± 9.59	
Median (IQR)	8.4 (6.2–13.1)	10.3 (6.8–19.1)	< 0.001	7.8 (5.9–11.0)	8.9 (6.2–18.3)	< 0.001
Re-admission within 10days	106 (5.2)	162 (4.6)	0.308	11 (2.8)	15 (3.4)	0.639
Re-admission within 30days	240 (11.8)	381 (10.8)	0.268	37 (9.5)	35 (7.9)	0.417

Data are presented as mean ± standard deviation, number (%) or median (IQR). KTAS = Korean Triage and Acuity Scale, HG = hospitalist group, NHG = non-hospitalist group, ACCI = Age-adjusted Charlson Comorbidity Index, IQR = interquartile range, CPR = Cardiopulmonary resuscitation, IHM = in-hospital mortality, ICU = intensive care unit, GI = gastrointestinal, APACHE = Acute Physiology and Chronic Health Evaluation, LOS = length of hospital stay, ED = emergency department

Table 3
Analysis of variables for patients with different comorbidity severities treated by hospitalists or non-hospitalists (N = 6391)

	ACCI: 0–2 (N = 1747)			**ACCI: 3 (N = 1169)**		
Variable	HG (n = 729)	NHG (n = 1018)	*p*	HG (n = 436)	NHG (n = 733)	*p*
CPR incidence	2 (0.3)	6 (0.6)	0.336	1 (0.2)	9 (1.2)	0.073
IHM	11 (1.5)	29 (2.8)	0.065	15 (3.4)	52 (7.1)	0.009
ICU admission	19 (2.6)	78 (7.7)	< 0.001	11 (2.5)	66 (9.0)	< 0.001
Cause of ICU admission (n = 438)						
Close monitoring after procedure or operation	11 (57.9)	62 (79.5)	0.081	7 (63.6)	38 (57.6)	0.927
Respiratory failure or insufficiency	6 (31.6)	8 (10.3)		2 (18.2)	19 (28.8)	
Septic shock	2 (10.5)	3 (3.8)		1 (9.1)	4 (6.1)	
Cardiovascular failure or insufficiency	0 (0.0)	2 (2.6)		1 (9.1)	4 (6.1)	
Metabolic/Renal failure	0 (0.0)	3 (3.8)		0 (0.0)	0 (0.0)	
GI bleeding	0 (0.0)	0 (0.0)		0 (0.0)	1 (1.5)	
Neurogenic dysfunction	0 (0.0)	0 (0.0)		0 (0.0)	0 (0.0)	
APACHE II score of ICU admission (n = 438)	25.68 ± 10.37	15.99 ± 11.73	0.001	31.18 ± 11.55	22.97 ± 12.47	0.045
LOS	7.91 ± 7.84	9.00 ± 10.42		9.82 ± 10.85	11.13 ± 12.10	
Median (IQR)	5 (4–9)	6 (4–10)	0.017	6 (4–11)	7 (5–13)	0.065
ED waiting time	10.36 ± 7.73	12.69 ± 8.96		10.47 ± 6.98	14.12 ± 11.01	
Median (IQR)	7.9 (5.7–11.8)	9.6 (6.4–17.4)	< 0.001	8.0 (6.0-12.5)	10.2 (6.6–20.0)	< 0.001
Re-admission within 10 days	33 (4.5)	32 (3.1)	0.132	16 (3.7)	30 (4.1)	0.719
Re-admission within 30 days	60 (8.2)	74 (7.3)	0.457	46 (10.6)	70 (9.5)	0.580

Table 3
(Continued)

	ACCI: 4 (N = 1445)			ACCI: ≥5 (N = 2030)		
Variable	HG (n = 502)	NHG (n = 943)	*p*	HG (n = 759)	NHG (n = 1271)	*p*
CPR incidence	3 (0.6)	13 (1.4)	0.177	9 (1.2)	7 (0.6)	0.117
IHM	23 (4.6)	109 (11.6)	< 0.001	68 (9.0)	171 (13.5)	0.002
ICU admission	13 (2.6)	85 (9.0)	< 0.001	52 (6.9)	114 (9.0)	0.092
Cause of ICU admission (n = 438)						
Close monitoring after procedure or operation	5 (38.5)	54 (63.5)	0.051	32 (61.5)	69 (60.5)	0.175
Respiratory failure or insufficiency	3 (23.1)	22 (25.9)		12 (23.1)	29 (25.4)	
Septic shock	2 (15.4)	3 (3.5)		2 (3.8)	7 (6.1)	
Cardiovascular failure or insufficiency	1 (7.7)	3 (3.5)		5 (9.6)	3 (2.6)	
Metabolic/Renal failure	0 (0.0)	1 (1.2)		0 (0.0)	4 (3.5)	
GI bleeding	2 (15.4)	1 (1.2)		1 (1.9)	0 (0.0)	
Neurogenic dysfunction	0 (0.0)	1 (1.2)		0 (0.0)	2 (1.8)	
APACHE Ⅱ score of ICU admission (n = 438)	21.85 ± 11.29	23.80 ± 12.47	0.596	24.60 ± 10.13	21.99 ± 10.62	0.139
LOS	10.39 ± 9.13	11.59 ± 11.11		13.65 ± 15.42	13.34 ± 14.33	
Median (IQR)	8 (5–12)	8 (6–14)	0.038	10 (6–15)	9 (6–15)	0.314
ED waiting time	10.95 ± 7.75	13.57 ± 10.08		12.73 ± 10.10	14.49 ± 10.37	
Median (IQR)	8.4 (6.1–12.2)	10.1 (6.7–18.7)	< 0.001	9.0 (6.6–15.0)	10.8 (7.0-20.3)	< 0.001
Re-admission within 10 days	20 (4.0)	45 (4.8)	0.491	48 (6.3)	70 (5.5)	0.447
Re-admission within 30 days	62 (12.4)	104 (11.0)	0.453	109 (14.4)	168 (13.2)	0.468

Data are presented as the mean ± standard deviation, the number (%), or the median (IQR), as indicated. ACCI = Age-adjusted Charlson Comorbidity Index, HG = hospitalist group, NHG = non-hospitalist group, CPR = Cardiopulmonary resuscitation, IHM = in-hospital mortality, IQR = interquartile range, ICU = intensive care unit, GI = gastrointestinal, APACHE = Acute Physiology and Chronic Health Evaluation, LOS = length of hospital stay, ED = emergency department

Multiple regression analysis of associations between clinical factors and major outcomes

We performed logistic regression analyses to adjust clinical variables potentially associated with the four major outcomes: IHM, ICU admission, re-admission within 10 days, and re-admission within 30 days (Table 4).

Logistic regression analysis revealed significantly lower rates of IHM (odds ratio [OR]: 0.46; 95% confidence interval [CI]: 0.34–0.63; $P < 0.001$) and ICU admission (OR: 0.39; 95% CI: 0.28–0.55; $P < 0.001$) in the hospitalist group compared to the non-hospitalist group. However, there was no significant difference in the re-admission rates within 10 or 30 days between the two groups (10-day rates: $P = 0.493$, 30-day rates: $P = 0.201$).

We also performed linear regression analyses to adjust clinical factors associated with LOS and the ED waiting time (Table 5). Both the LOS (coefficient: -1.349, standard error [SE]: 0.217; $p < 0.001$) and ED waiting times (coefficient: -3.021, SE: 0.256; $p < 0.001$) were significantly shorter in the hospitalist group than in the non-hospitalist group.

Table 4
logistic regression analysis of factors potentially associated with IHM, re-admissions, and ICU admission (N = 6391)

Variables	**IHM**		**Re-admission (10 days)**		**Re-admission (30 days)**		**ICU admission**	
	Odds ratio (95%CI)	*p*	Odds ratio (95%CI)	*p*	Odds ratio (95%CI)	*p*	Odds ratio (95%CI)	*p*
HG (ref = NHG)	0.46 (0.34, 0.63)	< 0.001	0.89 (0.65,1.24)	0.493	0.87 (0.69,1.08)	0.201	0.39 (0.28, 0.55)	< 0.001
Female (ref = male)	0.76 (0.62, 0.95)	0.014	0.94 (0.73,1.20)	0.597	0.89 (0.75, 1.05)	0.158	0.73 (0.57, 0.93)	0.012
Age	1.02 (1.01, 1.03)	< 0.001	0.99 (0.98,1.00)	0.193	0.99 (0.99, 1.00)	0.057	1.00 (0.99, 1.01)	0.844
Prior hospitalization	1.06 (1.04, 1.08)	< 0.001	1.05 (1.03,1.07)	< 0.001	1.05 (1.03, 1.07)	< 0.001	0.95 (0.91, 0.98)	0.004
KTAS (ref = more urgent group)[a]	0.63 (0.43, 0.92)	0.019	0.64 (0.42,0.97)	0.035	0.78 (0.60, 1.01)	0.061	0.81 (0.53, 1.23)	0.319
ACCI	1.09 (1.04, 1.14)	0.001	1.06 (1.00,1.12)	0.045	1.07 (1.03, 1.11)	0.001	1.01 (0.94, 1.07)	0.857
ED Waiting Time	1.02 (1.01, 1.03)	< 0.001	1.00 (0.99,1.02)	0.532	1.00 (1.00, 1.01)	0.308	0.99 (0.98, 1.00)	0.152
LOS	0.99 (0.98, 1.00)	0.175	1.01 (0.98,1.02)	0.558	1.00 (0.99, 1.00)	0.702	0.99 (0.98, 1.11)	0.101
CPR incidence (ref = No)	46.32 (19.94,107.56)	< 0.001	0.00 (0.00, -)	0.997	0.16 (0.02, 1.19)	0.073	29.78 (14.00, 63.33)	< 0.001
ICU admission (ref = No)	4.42 (3.04, 6.42)	< 0.001	0.50 (0.26,0.94)	0.031	0.56 (0.37, 0.85)	0.006		
Referral to specialty (ref = No)	0.93 (0.68, 1.25)	0.611	1.24 (0.89,1.74)	0.198	1.31 (1.04, 1.64)	0.021	2.84 (2.06, 3.92)	< 0.001
Operation (ref = No)	0.44 (0.31, 0.63)	< 0.001	1.20 (0.84,1.70)	0.320	1.01 (0.79, 1.30)	0.943	3.67 (2.73, 4.92)	< 0.001

IHM = in-hospital mortality, ICU = intensive care unit, 95%CI = 95% confidence interval, HG = hospitalist group, ref = reference group, NHG = non-hospitalist group, KTAS = Korean Triage and Acuity Scale, [a]the less urgent group with KTAS = 4–5 was compared to the more urgent group with KTAS = 1–3;, ACCI = Age-adjusted Charlson Comorbidity Index, ED = emergency department, LOS = length of hospital stay, CPR = Cardiopulmonary resuscitation

Variables	IHM		Re-admission (10 days)		Re-admission (30 days)		ICU admission	
Consultation	1.04 (1.01, 1.06)	0.002	1.01 (0.98,1.04)	0.506	1.01 (0.99, 1.03)	0.350	1.13 (1.10, 1.16)	< 0.001
Diseases (ref = malignant neoplasms)								
Circulatory system	0.09 (0.05, 0.15)	< 0.001	0.67 (0.40,1.13)	0.132	0.65 (0.46, 0.91)	0.014	17.90 (11.96, 26.77)	< 0.001
Respiratory system	0.44 (0.33, 0.60)	< 0.001	0.67 (0.46,0.99)	0.045	0.69 (0.53, 0.90)	0.005	2.21 (1.47, 3.31)	< 0.001
Digestive system	0.17 (0.11, 0.27)	< 0.001	0.67 (0.44,1.01)	0.056	0.59 (0.44, 0.78)	< 0.001	0.74 (0.42, 1.30)	0.289
Genitourinary system	0.08 (0.04, 0.16)	< 0.001	0.43 (0.24,0.75)	0.003	0.52 (0.40, 0.74)	< 0.001	0.66 (0.35, 1.22)	0.181
Symptoms, signs and abnormal clinical and laboratory findings	0.17 (0.08, 0.37)	< 0.001	0.88 (0.50, 1.56)	0.656	0.65 (0.43, 1.00)	0.048	0.85 (0.38, 1.90)	0.692
Certain infectious and parasitic diseases	0.29 (0.16, 0.54)	< 0.001	0.70 (0.37, 1.34)	0.284	0.50 (0.31, 0.82)	0.006	1.15 (0.57, 2.31)	0.699
Endocrine, nutritional and metabolic diseases	0.02 (0.00, 0.15)	< 0.001	0.77 (0.40, 1.47)	0.431	0.81 (0.53, 1.24)	0.330	0.49 (0.15, 1.59)	0.234
Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism	0.38 (0.17, 0.85)	0.018	0.48 (0.19, 1.21)	0.118	0.78 (0.47, 1.29)	0.325	0.72 (0.23, 2.31)	0.584

IHM = in-hospital mortality, ICU = intensive care unit, 95%CI = 95% confidence interval, HG = hospitalist group, ref = reference group, NHG = non-hospitalist group, KTAS = Korean Triage and Acuity Scale, [a]the less urgent group with KTAS = 4–5 was compared to the more urgent group with KTAS = 1–3;, ACCI = Age-adjusted Charlson Comorbidity Index, ED = emergency department, LOS = length of hospital stay, CPR = Cardiopulmonary resuscitation

Variables	IHM		Re-admission (10 days)		Re-admission (30 days)		ICU admission	
Diseases of the musculoskeletal system and connective tissue	0.12 (0.04, 0.38)	< 0.001	0.37 (0.12, 1.21)	0.099	0.24 (0.10, 0.59)	0.002	1.69 (0.74, 3.84)	0.211
Others	0.25 (0.14, 0.47)	< 0.001	0.70 (0.37, 1.32)	0.270	0.59 (0.38, 0.92)	0.021	1.22 (0.62, 2.43)	0.565

IHM = in-hospital mortality, ICU = intensive care unit, 95%CI = 95% confidence interval, HG = hospitalist group, ref = reference group, NHG = non-hospitalist group, KTAS = Korean Triage and Acuity Scale, [a]the less urgent group with KTAS = 4–5 was compared to the more urgent group with KTAS = 1–3;, ACCI = Age-adjusted Charlson Comorbidity Index, ED = emergency department, LOS = length of hospital stay, CPR = Cardiopulmonary resuscitation

Table 5
Linear regression analysis for LOS and ED waiting time (N = 6391)

Variables	**LOS**			**ED Waiting Time**		
	coefficient	SE	*p*	coefficient	SE	*p*
(constant)	5.988	0.403	< .001	13.281	0.563	< .001
HG (ref = NHG)	-1.349	0.217	< .001	-3.021	0.256	< .001
Female (ref = male)	0.179	0.164	0.275	-0.043	0.241	0.857
Age	-0.013	0.006	0.030	0.006	0.009	0.535
ACCI	0.218	0.046	< .001	0.317	0.066	< .001
KTAS[a] (ref = more urgent group)	-0.121	0.242	0.616	-1.161	0.356	0.001
Prior hospitalization	0.018	0.020	0.371	0.090	0.029	0.002
ED Waiting Time	0.015	0.009	0.087			
CPR (ref = No)	1.332	0.953	0.162			
ICU admission (ref = No)	-0.753	0.365	0.039			
Referral to specialty (ref = No)	2.361	0.227	< .001			
Consultation	1.443	0.014	< .001			
IMH	-0.584	0.328	0.074			
Operation (ref = No)	0.749	0.260	0.004			
Diseases (ref = malignant neoplasms)						
Diseases of the circulatory system	-1.749	0.340	< .001	-3.471	0.478	< .001
Diseases of the respiratory system	1.254	0.272	< .001	-2.535	0.396	< .001
Diseases of the digestive system	-2.279	0.286	< .001	0.090	0.419	0.830
Diseases of the genitourinary system	-3.368	0.325	< .001	-0.807	0.473	0.088
Symptoms, signs and abnormal clinical and laboratory findings	-2.474	0.401	< .001	-1.865	0.588	0.002
Certain infectious and parasitic diseases	-1.092	0.422	0.010	-0.547	0.620	0.378
Endocrine, nutritional and metabolic diseases	-2.166	0.441	< .001	-1.201	0.646	0.063
Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism	-1.210	0.516	0.019	-1.931	0.756	0.011

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, IQR = interquartile range, ICU = intensive care unit, LOS = length of hospital stay, ED = emergency department, [a]the less urgent group with KTAS = 4–5 was compared to the more urgent group with KTAS = 1–3;, SE: standard error

Variables	LOS			ED Waiting Time		
Diseases of the musculoskeletal system and connective tissue	1.631	0.563	0.004	0.486	0.824	0.555
Others	-2.191	0.430	< .001	0.403	0.628	0.522
	Adj- R2 = 0.723, F = 727.330 (p < .001)			Adj- R2 = 0.043, F = 18.884 (p < .001)		

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, IQR = interquartile range, ICU = intensive care unit, LOS = length of hospital stay, ED = emergency department, [a]the less urgent group with KTAS = 4–5 was compared to the more urgent group with KTAS = 1–3;, SE: standard error

Discussions

This study was the first to report the outcomes of a Korean AMU hospitalist model with additional adjustments for patient-related clinical factors. We found lower IHM and ICU admission rates and shorter LOS and ED waiting times with AMU hospitalist care compared to non-hospitalist care. The same trend was observed in the subgroup and multiple regression analyses. However, there was no significant difference in the re-admission rates between patients cared for by hospitalists and those cared for by non-hospitalists

These results suggested that adequate, rapid management by hospitalists in the early phase of an acute illness and their efficient operation of the AMU have contributed to improved patient outcomes. The strength of our AMU care is the direct, real-time communication among variously trained team members, which facilitated making appropriate, rapid treatment decisions for patients with acute conditions [11]. The AMU at our institution was different from typical emergency short-stay units operated by emergency physicians, mainly because the AMU follows these essential principles: intensive, active care, multi-disciplinary teamwork, and rapid diagnostics and therapy [12].

Previous studies that investigated the impact of AMU or hospitalist care have reported that IHM was reduced with hospitalist care [7, 8, 10, 21–28]. Contrary to those studies, another report found no significant difference in mortality between patients treated by a hospitalist and those treated by a non-hospitalist [29–34]. Moreover, a recent Korean study found no difference in IHM between hospitalist and non-hospitalist care in the integrated medical model [34].

Although those results were conflicting, in our institute, AMU hospitalist care was more effective than non-hospitalist care in reducing patient mortality. Our findings provided evidence that a hospitalist-run AMU was an effective model that significantly reduced IHM among patients with acute medical needs. This study also demonstrated that the existing British acute medicine model was effectively transformed into a Korean AMU model.

Few studies have reported ICU admission rates in AMU care. One study on a surgical co-management model, which mainly focused on patients that required surgery, found a significant reduction in the ICU admission rate in the hospitalist group [35], compared to the non-hospitalist group. Other studies have reported no significant difference the ICU admission rates between the two types of care [36–38]. However, in our study, the ICU admission rate decreased significantly with AMU hospitalist care. This finding implied that hospitalists in the AMU effectively treated patients with acute medical needs, and greatly contributed to stabilizing their conditions without ICU admission. This result showed that the new, effective AMU hospitalist care in Korea could reduce ICU admission through efficient, high-quality treatment for patients that require acute medical care.

Most studies on acute medicine have reported that hospitalist care could reduce LOS compared to non-hospitalist care [7–10, 21–23, 30, 31, 33, 34, 39–47]. In contrast, others have found that hospitalist care resulted in longer LOS or did not significantly affect LOS [32, 48, 49]. Despite those conflicting results, in our institute, AMU hospitalist care reduced the total LOS, compared to care from non-hospitalists. Recently, another study reported that hospitalist care within the integrated medical model of Korea showed a reduction in LOS, particularly in patients with multiple comorbidities [34]. According to that study, patients that received hospitalist care had shorter LOS, for several reasons. One reason was that the hospitalists were better trained than residents; consequently, they could manage diseases from more perspectives, which increased the likelihood of resolving the condition [34]. That finding suggested that Korean hospitalist care might significantly shorten LOS, regardless of the type of care model applied.

Some studies showed that AMU hospitalist care significantly shortened the ED waiting time, compared to non-hospitalist care [7–9, 23]. Consistent with previous studies, in our institution, AMU care also reduced the ED waiting time. This result might be explained by an increase in the bed turnover rate and an alleviation of delays caused by waiting inpatients.

In our study, AMU hospitalist care was not associated with a significant difference in unscheduled re-admissions. Previous studies showed that hospitalist care led to significantly lower re-admission rates, compared to non-hospitalist care [10, 21, 22, 29, 39, 48, 50]. Others found no significant difference in the re-admission rate [30, 32–34, 40–44]. Those results suggested that the re-admission rate might depend on the type of hospitalist care model applied, disease-related factors, and the hospitalist's roles. Shu et al. (2011) reported that, when a hospitalist provided post-discharge transitional care by telephone to discharged patients, the re-admission rate was significantly reduced [50]. Some studies have found that an AMU significantly reduced the re-admission rate [51], but most studies on the effects of acute medicine found no effect of hospitalist care on the rate of unscheduled re-admissions [42, 43]. In our institution, AMU hospitalist care was focused on the acute treatment of inpatients admitted through the ED; therefore, we did not expect a significant impact on the post-discharge readmission rate.

In summary, we provided evidence that AMU hospitalist care in a Korean tertiary care hospital reduced IHM, ICU admission, LOS, and ED waiting time.

Our study had some limitations: (1) it had a retrospective design, and it was limited to a single institution; (2) it was difficult to distinguish whether the effects on outcomes were due to the AMU setting or the care provided by the hospitalists; (3) we did not evaluate patient or staff satisfaction; and (4) we did not perform an economic evaluation, including the medical costs. Future studies are necessary to determine whether the introduction of the AMU will improve patient health in the long term, increase patient or staff satisfaction, and improve the cost-effectiveness of patient care.

Conclusions

South Korea adopted both the UK's AMU and the US's hospitalist model and applied a combined care model. This is the answer to the increase in the complexity and severity of inpatient care in internal medicine due to the increase in patient with complex diseases, various chronic, tumor, and immune diseases [4]. Our study showed that the AMU Hospitalist care model of South Korea improved patient outcomes. This care model may be applied in some hospitals. However, it is necessary to apply a different care model depending on the situation (number of beds, human resources, needs) and culture of individual hospitals [4]. In addition, it is necessary to evaluate the effectiveness of various hospitalist care models.

Abbreviations

AMU: Acute Medical Unit; HG: hospitalist group; NHG: non-hospitalist group; IHM: in-hospital mortality; ICU: intensive care unit; LOS: length of hospital stay; ED: emergency department; ACCI: Age-adjusted Charlson Comorbidity Index; KTAS: Korean Triage and Acuity Scale; APACHE: Acute Physiology and Chronic Health Evaluation; CPR: Cardiopulmonary resuscitation; IQR: interquartile range; GI: gastrointestinal

Declarations

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Authors’ contributions

KHJ and KJH conceptualized the study. KHJ performed data extraction, processing and analyses. KJH, OJH and KNH contributed to study design and analytical approach. KHJ prepared the draft of the manuscript and all the coauthors revised the draft critically.

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Availability of data and materials

No data are available.

Ethics approval and consent to participate

Ethical approval was confirmed by the Institutional Review Board of Seoul National University Bundang Hospital (IRB No. B-1711/435-107)

Consent for publication

Not appicable.

Competing interests

The authors declare that they have no competing interests.

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Figures

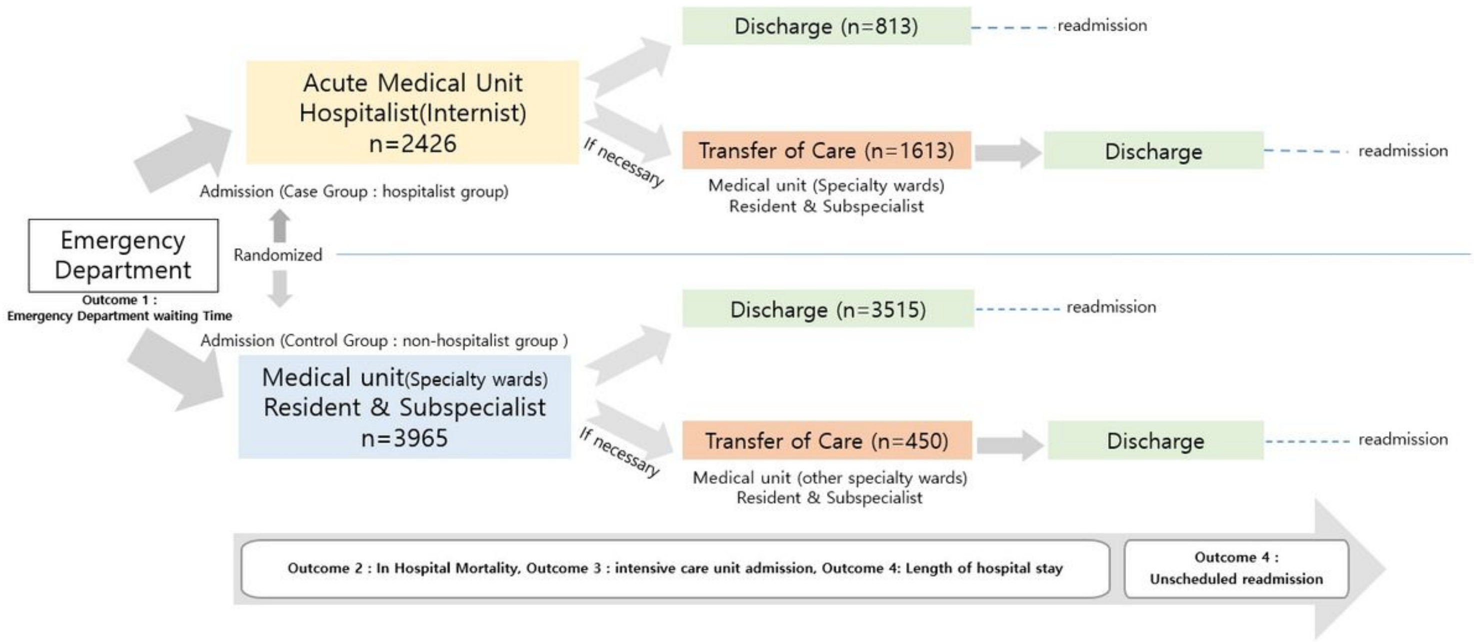

Figure 1

Flow diagram of the study population

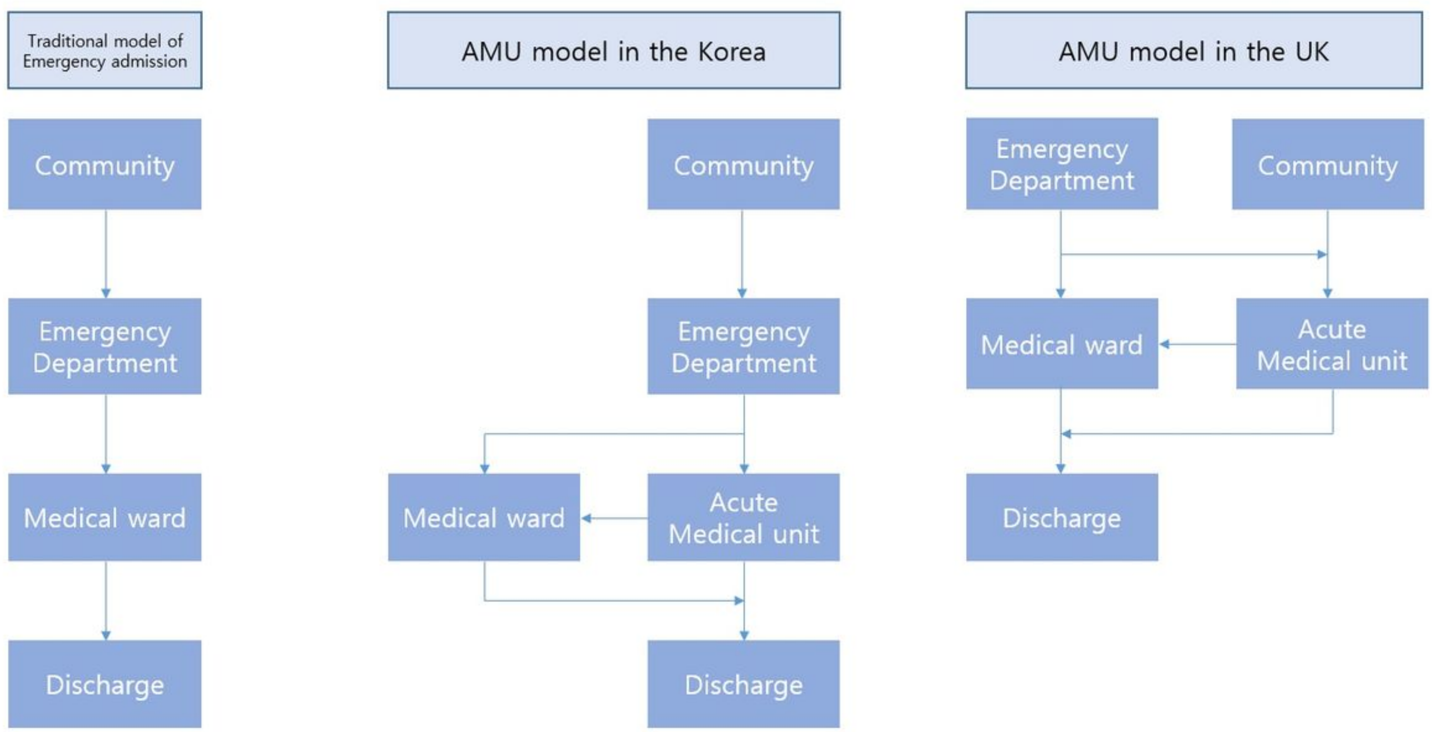

Figure 2

Models of acute admissions (traditional model, AMU in the South Korea, AMU in the UK).This figure has been reproduced with permission from [Elsevier]

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