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Reasons and Risk Factors for Readmission Following Hospitalization for Community-acquired Pneumonia in South Korea

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Background: Limited studies have been performed to assess readmission following hospitalization for community-acquired pneumonia (CAP) in an Asian population. We evaluated the rates, reasons, and risk factors for 30-day readmission following hospitalization for CAP in the general adult population of Korea.
Methods: We performed a retrospective observational study of 1,021 patients with CAP hospitalized at Yeungnam University from March 2012 to February 2014. The primary end point was all-cause hospital readmission within 30 days following discharge after the initial hospitalization. Hospital readmission was classified as pneumonia-related or pneumonia-unrelated readmission.
Results: During the study period, 862 patients who survived to hospital discharge were eligible for inclusion and among them 72 (8.4%) were rehospitalized within 30 days. In the multivariable analysis, pneumonia-related readmission was associated with para/hemiplegia, malignancy, pneumonia severity index class ≥4 and clinical instability ≥1 at hospital discharge. Comorbidities such as chronic lung disease and chronic kidney disease, treatment failure, and decompensation of comorbidities were associated with the pneumonia-unrelated 30-day readmission rate.
Conclusion: Rehospitalizations within 30 days following discharge were frequent among patients with CAP. The risk factors for pneumonia-related and -unrelated readmission were different. Aspiration prevention, discharge at the optimal time, and close monitoring of comorbidities may reduce the frequency of readmission among patients with CAP.

Keywords: Causes; Hospital Readmission; Koreans; Pneumonia; Risk Factors

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Introduction

Pneumonia is an important cause of morbidity and mortality worldwide. It is the seventh-leading cause of death in the United States, where about 915,900 episodes of pneumonia occur annually in adults aged ≥65 years[1]. In Korea, pneumonia ranked tenth (7.1 deaths per 100,000 population) among all causes of death in 2004 and sixth (21.4 deaths per 100,000 population) in 2013[2]. The incidence and direct medical costs of hospitalized pneumonia are consistently high in Korea. Persons aged ≥75 years, and those with underlying medical conditions, are at increased risk of hospitalization due to pneumonia[3].

Pneumonia is a frequent cause of rehospitalization after discharge; generalized vulnerability to illness also contributes to the development of acute conditions requiring rehospitaliza-

tion[4].

The 30-day readmission after hospitalization for pneumonia is related to the rate of 30-day mortality after discharge[5]. Moreover, pneumonia readmission rates are associated with increased medical costs and are used as an indicator of quality of care[6]. Patient-, disease-, physician-, and healthcare system-related factors are associated with pneumonia readmissions and are targets of interventions to reduce the rate of readmission for pneumonia[7]. Clinically, identification of the reasons and risk factors for readmission is important for discharge planning.

The rates, reasons, and risk factors for pneumonia readmission vary among populations, regions, and methodologies. Most prior readmission studies were conducted in North America and Europe. One Korean study assessed only healthcare system-related factors in elderly (age ≥65 years) pneumonia patients using nationwide data[6]. Although pneumonia is a frequent cause of readmission, which is related to several modifiable factors, few Asian studies have investigated hospital readmission for pneumonia. Here we evaluated the rates, reasons, and risk factors for 30-day readmission following hospitalization for community-acquired pneumonia (CAP) in the general adult population of Korea.

Materials and Methods

1. Study design and subjects

We performed a retrospective observational study of 1,021 patients with CAP hospitalized at Yeungnam University Hospital (a 930-bed, university-affiliated, tertiary referral hospital in Daegu, Korea) from March 2012 to February 2014. The total number of patients enrolled in this study does not differ from previous publication and this study is a secondary analysis of previous publication using same database[8]. In this study, we added health insurance status as an independent factor. However, we could not find health insurance status in 10 patients based on electronic medical records. Thus, we excluded these patients first.

As described in detail previously[8], during the study period, all consecutive adult patients (age ≥18 years) with CAP admitted to the hospital via the emergency or outpatient department were eligible for inclusion. Patients with hospital-acquired pneumonia that developed more than 48 hours after admission, those aged below 18 years, immunocompromised patients (such as those with neutropenia after chemotherapy, human immunodeficiency virus infection, solid organ transplant recipients, or receiving corticosteroids or other immunosuppressive agents), patients with active *Mycobacteria tuberculosis* infection, and patients registered twice were not included in this study. The exclusion criteria were patients who (1) died during the index hospitalization, (2) discharged themselves against medical advice and refused outpatient follow-up, or (3) were transferred to another acute-care facility (Figure 1).

2. Data collection and definitions

Patient electronic medical records were reviewed by two physicians (J.G.J. and J.H.A.). Clinical data included age, gender, comorbidities, vital signs, feeding status, mental status, ambulatory status and laboratory findings. We assessed disease burden using the Charlson comorbidity index (CCI)[9], which assigns a weighted score to each comorbid condition depending on the risk of 1-year mortality.

Medical Aid beneficiaries were considered to have a lower socioeconomic status than National Health Insurance beneficiaries. The severity of pneumonia was assessed using the pneumonia severity index (PSI)[10] and CURB-65 score[11] on day 1 of hospitalization.

Inappropriate initial antibiotic therapy (IIAT) was defined as non-susceptibility to the initially prescribed empirical antibiotic by *in vitro* antibiotic susceptibility testing.

Treatment failure was defined as clinical deterioration during hospitalization with any of the following: (1) progression of pneumonia on radiographs, (2) respiratory failure, (3) need for mechanical ventilation, (4) hemodynamic instability, or (5) development of a new infection focus[12]. Patients were defined as having decompensation of comorbidity if the medical records suggested exacerbation of one or more comorbidities

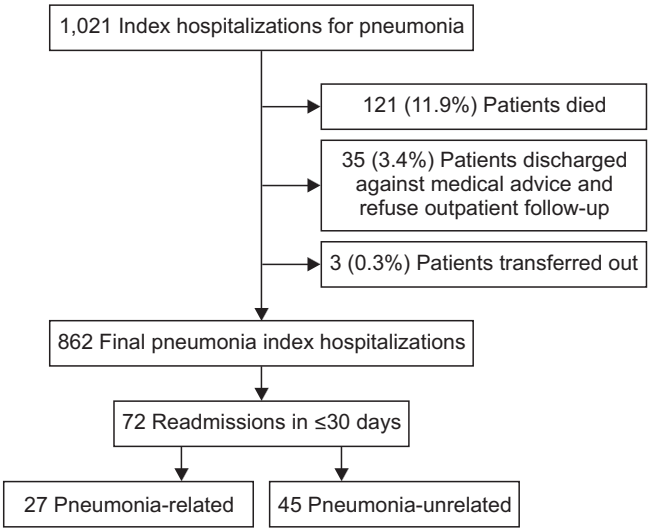

Figure 1. Study design: 1,021 index hospitalizations for community-acquired pneumonia were identified. After excluding patients who died during the index hospitalization, those who discharged themselves against medical advice and refused outpatient follow-up, and those transferred to another acute care facility, the final cohort comprised 862 patients.

Table 1. Characteristics and outcomes of the patients (n=862)

Characteristic	Entire population	Readmission (n=72)	Non-readmission (n=790)	p-value
Host-related				
Male sex	565 (65.5)	55 (76.4)	510 (64.6)	0.043
Age, yr	68.5±14.6	72.3±10.8	68.1±14.9	0.003
Age ≥65 yr	596 (69.1)	60 (83.3)	536 (67.8)	0.006
Comorbidities				
Congestive heart failure	64 (7.4)	8 (11.1)	56 (7.1)	0.213
Cerebrovascular disease	167 (19.4)	21 (29.2)	146 (18.5)	0.028
Dementia	57 (6.6)	6 (8.3)	51 (6.5)	0.464
Chronic lung disease*	281 (32.6)	38 (52.8)	243 (30.8)	<0.001
Connective tissue disease	16 (1.9)	1 (1.4)	15 (1.9)	1.000
Diabetes mellitus	182 (21.1)	17 (23.6)	165 (20.9)	0.588
Para/hemiplegia	64 (7.4)	13 (18.1)	51 (6.5)	<0.001
Chronic kidney disease	38 (4.4)	7 (9.7)	31 (3.9)	0.032
Malignancy	88 (10.2)	17 (23.6)	71 (9.0)	<0.001
Old myocardial infarction	30 (3.5)	2 (2.8)	28 (3.5)	1.000
Peripheral vascular disease	74 (8.6)	8 (11.1)	66 (8.4)	0.424
Liver disease	25 (2.9)	1 (1.4)	24 (3.0)	0.714
CCI	1.6±1.5	2.5±1.7	1.5±1.4	<0.001
CCI ≥1	626 (72.6)	69 (95.8)	557 (70.5)	<0.001
CCI ≥2	370 (42.9)	49 (68.1)	321 (40.6)	<0.001
Medical aid	65 (7.5)	6 (8.3)	59 (7.5)	0.790
Tube feeding†	55 (6.4)	8 (11.1)	47 (5.9)	0.123
Drowsiness/stupor	51 (5.9)	6 (8.3)	45 (5.7)	0.428
Nonambulatory status‡	130 (15.1)	17 (23.6)	113 (14.3)	0.035
Severity				
CURB-65	1.5±1.0	1.7±1.0	1.5±1.0	0.030
CURB-65 ≥3	142 (16.5)	17 (23.6)	125 (15.8)	0.088
PSI	99.2±28.4	110.4±23.6	98.2±28.5	<0.001
PSI class ≥IV	549 (63.7)	58 (80.6)	491 (62.2)	0.002
ICU admission	39 (4.5)	1 (1.4)	38 (4.8)	0.244
Mechanical ventilator	42 (4.9)	2 (2.8)	40 (5.1)	0.569
Treatment				
IIAT	74 (8.6)	7 (9.7)	67 (8.5)	0.719
In-hospital evolution				
Treatment failure	72 (8.4)	16 (22.2)	56 (7.1)	<0.001
Decompensation of comorbidity	166 (19.3)	26 (36.1)	140 (17.7)	<0.001
Clinical instability	0.08±0.30	0.19±0.43	0.07±0.28	0.022
0	796 (92.3)	59 (81.9)	737 (93.3)	0.001
≥1	66 (7.7)	13 (18.1)	53 (6.7)	
Hospital days	11.6±12.5	13.8±9.4	11.4±12.7	0.867

Table 1. Continued

Characteristic	Entire population	Readmission (n=72)	Non-readmission (n=790)	p-value
Microorganisms				
MDR pathogen	79 (9.2)	7 (9.7)	72 (9.1)	0.864
MRSA	21 (2.4)	2 (2.8)	19 (2.4)	0.693
ESBL producing Enterobacteriaceae	25 (2.9)	3 (4.2)	22 (2.8)	0.457
MDR pseudomonas	18 (2.1)	2 (2.8)	16 (2.0)	0.657
Lab				
Albumin	3.3±0.6	3.1±0.7	3.3±0.6	0.008
Lactate	1.6±1.1	1.6±0.8	1.6±1.1	0.732
NT-ProBNP	1,020.9±2,648.9	960.9±1,446.9	1,026.6±2,736.1	0.841
CRP	10.8±10.1	11.9±9.1	10.7±10.2	0.311
Procalcitonin	3.0±15.2	1.5±4.6	3.2±15.9	0.368
BUN	17.2±11.4	18.5±12.0	17.1±11.4	0.312
Creatinine	1.2±0.8	1.3±0.8	1.2±0.8	0.166
Hematocrit	36.1±5.8	35.7±7.6	36.2±5.6	0.599
Sodium	136.8±4.9	135.9±5.6	136.9±4.8	0.088
PaO_2/FiO_2 ratio	319.6±87.7	291.0±85.8	322.2±87.5	0.004
PaO_2	70.5±20.1	64.6±16.8	71.0±20.3	0.010
$PaCO_2$	36.8±21.0	39.5±30.5	36.6±19.9	0.257
pH	7.4±0.7	7.4±0.7	7.4±0.7	0.615
Platelet	285.1±117.7	284.0±111.1	285.2±118.4	0.936
Pleural effusion	140 (16.2)	14 (19.4)	126 (15.9)	0.441

Values are presented as number (%) or mean±SD (range).
*Chronic lung disease includes chronic obstructive pulmonary disease, asthma, bronchiectasis, and interstitial lung disease. †Tube feeding includes nasogastric tube and gastrostomy tube feeding. ‡Nonambulatory status is defined as using a wheelchair for ambulation or being bedridden.
CCI: Charlson comorbidity index; PSI: pneumonia severity index; ICU: intensive care unit; IIAT: inappropriate initial antibiotic therapy; MDR: multidrug-resistant; MRSA: methicillin-resistant *Staphylococcus aureus*; ESBL: extended-spectrum beta-lactamase; NT-ProBNP: N-terminal probrain natriuretic peptide; CRP: C-reactive protein; BUN: blood urea nitrogen; PaO_2: partial pressure of oxygen; FiO_2: fraction of inspired oxygen; $PaCO_2$: partial pressure of carbon dioxide.

during hospitalization that required intensification of treatment[13], such as exacerbation of chronic lung disease, acute kidney injury in the presence of chronic kidney disease, or a rapid ventricular response in the form of atrial fibrillation.

We defined clinical instability within 24 hours before hospital discharge using established criteria. A patient with any of the following was considered to be unstable: (1) body temperature >37.8°C, (2) respiration rate >24 breaths/min, (3) heart rate >100 beats/min, (4) systolic blood pressure ≤90 mm Hg, or (5) oxyhemoglobin saturation measured by pulse oximetry <90% and partial pressure of oxygen in arterial blood <60 mm Hg[14]. Two other criteria used to define clinical instability at hospital discharge (inability to tolerate oral intake and an abnormal mental status) were not available in the medical records.

3. Outcome variables

The primary end point was all-cause hospital readmission within 30 days following discharge after the initial hospitalization. Hospital readmission was classified as (1) pneumonia-related or (2) pneumonia-unrelated readmission.

Pneumonia-related readmission was defined as the presence of (1) radiographic infiltration and (2) acute-onset symptoms suggestive of pneumonia using established criteria[13,15]. Pneumonia-unrelated readmission was defined as the existence of an alternative reason for readmission. Two investigators (J.H.A. and J.G.J.) reviewed the reasons for readmission independently; any discordance was resolved by consensus.

4. Statistical analysis

Continuous variables are expressed as mean±standard deviation and were compared by Student's t test or the Mann-Whitney U test. Categorical variables were compared by chi-squared test or Fisher exact test. Multivariable logistic regression analyses were performed to identify independent risk factors for hospital readmission using variables with a p-value of <0.1 in univariable analyses, as measured by the odds ratios (ORs) with 95% confidence intervals (CIs). A linear-by-linear association test was performed to analyze the 30-day hospital readmission rate according to the number of risk factors. In all analyses, p<0.05 by two-tailed test was considered to indicate statistical significance. All statistical procedures were performed using SPSS software version 21.0 (IBM Corp., Armonk, NY, USA).

5. Ethical statement

This study was conducted in accordance with the tenets of the Declaration of Helsinki, and was reviewed and approved by the Institutional Review Board of Yeungnam University Hospital (YUH IRB 2018-06-012). The requirement for informed consent was waived because of the retrospective study design.

Results

During the study period, 862 patients who survived to hospital discharge were eligible for inclusion and among them 72 (8.4%) were rehospitalized within 30 days. Pneumonia-related readmission accounted for 37.5% of the total number of readmissions within 30 days (Figure 1).

1. Baseline characteristics

The demographic and baseline characteristics of the patients are presented in Table 1. The mean age of the patients was 68.5 years, and 565 (65.5%) were males. Patients who were readmitted were older; predominantly male; and more likely to have cerebrovascular disease, chronic lung disease, para/hemiplegia, chronic kidney disease, and malignancy compared with non-readmitted patients. The mean CCI was higher in patients who were readmitted (2.5±1.7 vs. 1.5±1.4, p<0.001). The frequency of non-ambulatory status (requirement of a wheelchair for ambulation and being bedridden) was higher in readmitted than non-readmitted patients. The CURB-65 (1.7±1.0 vs. 1.5±1.0, p=0.030) and PSI (110.4±23.6 vs. 98.2±28.5, p<0.001) values were significantly higher in patients who were readmitted. With respect to in-hospital evolution, the rates of treatment failure, decompensation of comorbidity, and clinical instability at hospital discharge were significantly higher in readmitted than non-readmitted patients.

2. Reasons for rehospitalization

The reasons for rehospitalization were assessed in 72 patients. Pneumonia-related and -unrelated reasons accounted for 37.5% (3.13% of the total index hospitalizations) and 62.5% of the total hospital readmissions, respectively (Table 2).

3. Factors associated with hospital readmission

The factors associated with 30-day hospital readmission for pneumonia-related and -unrelated reasons are listed in Tables 3 and 4, respectively. In the multivariable analysis, pneumonia-related readmission was associated with para/hemiplegia, malignancy, PSI class ≥4 and clinical instability ≥1 at hospital discharge (Table 3). Comorbidities such as chronic

Table 2. Reasons for hospital readmission within 30 days after discharge (n=72)

Reason	No. (%)
Pneumonia-related*	27 (37.5)
Pneumonia-unrelated†	45 (62.5)
Cardiovascular	4 (5.6)
Pulmonary	15 (20.8)
Gastrointestinal	13 (18.1)
Orthopedic	1 (1.4)
Neurologic	1 (1.4)
Renal disorder	0 (0)
Neoplastic	2 (2.8)
Endocrine	0 (0)
Other‡	9 (12.5)

*Among patients readmitted for pneumonia-related reasons, 12 (44.4%) were readmitted due to aspiration pneumonia associated with comorbidities. †The pneumonia-unrelated reasons for readmission were as follows: cardiovascular reasons were atrial fibrillation with rapid ventricular response (n=2), acute decompensated heart failure (n=1), and multiple atrial tachycardia due to pulmonary disease (n=1); pulmonary reasons were acute exacerbations of chronic obstructive pulmonary disease (n=6), and idiopathic pulmonary fibrosis (n=3), hemoptysis (n=2), hypoventilation (n=1), pneumothorax (n=1), atelectasis (n=1), and operation for pulmonary causes (n=1); gastrointestinal reasons were gastrointestinal bleeding (n=5), *Clostridium difficile*–associated diarrhea (n=3), colitis (n=2), peritonitis (n=1), acute appendicitis (n=1), and acute cholangitis (n=1); the orthopedic reason was osteomyelitis of the coccyx (n=1); the neurologic reason was cerebrovascular accident (n=1); the neoplastic reason was lung cancer (n=2). ‡Other causes are urinary tract infection (n=4), tracheostomy malfunction (n=1), oral candidiasis (n=1), herpes zoster (n=1), paravertebral infection (n=1), and general weakness with poor oral intake (n=1).

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Table 3. Univariable and multivariable analyses of risk factors for pneumonia-related readmissions among patients with CAP

Prognostic factor	Univariable			Multivariable		
	OR	95% CI	p-value	OR	95% CI	p-value
Host-related						
Male sex	1.05	0.47–2.37	0.901	-	-	-
Age ≥65 yr	3.68	1.10–12.32	0.024	-	-	-
Comorbidities						
Congestive heart failure	1.00	0.23–4.31	1.000	-	-	-
Cerebrovascular disease	2.54	1.14–5.65	0.018	-	-	-
Dementia	1.14	0.26–4.92	0.698	-	-	-
Chronic lung disease*	1.44	0.66–3.14	0.359	-	-	-
Connective tissue disease	2.10	0.27–16.52	0.402	-	-	-
Diabetes mellitus	1.07	0.43–2.69	0.886	-	-	-
Para/hemiplegia	4.78	1.94–11.77	0.002	4.18	1.56–11.25	0.005
Chronic kidney disease	0.97	0.96–0.98	0.627	-	-	-
Malignancy	3.97	1.69–9.37	0.004	3.78	1.50–9.53	0.005
Old myocardial infarction	2.31	0.52–10.22	0.241	-	-	-
Peripheral vascular disease	1.35	0.40–4.58	0.499	-	-	-
Liver disease	1.30	0.17–9.98	0.554	-	-	-
CCI ≥1	10.18	1.37–75.47	0.005	-	-	-
CCI ≥2	3.28	1.42–7.57	0.003	-	-	-
Medical aid	0.46	0.06–3.47	0.714	-	-	-
Tube feeding†	4.58	1.77–11.88	0.005	-	-	-
Drowsiness/stupor	0.60	0.08–4.54	1.000	-	-	-
Nonambulatory status‡	2.46	1.05–5.75	0.050	-	-	-
Severity score						
CURB-65 ≥3	2.20	0.95–5.14	0.068	-	-	-
PSI class ≥IV	15.51	2.09–114.86	<0.001	10.01	1.338–75.51	0.025
ICU admission	0.97	0.96–0.98	0.629	-	-	-
Mechanical ventilator	0.75	0.10–5.63	1.000	-	-	-
Treatment						
IIAT	1.35	0.40–4.58	0.499	-	-	-
In-hospital evolution						
Treatment failure	4.15	1.69–10.17	0.005	-	-	-
Decompensation of comorbidity	1.49	0.62–3.58	0.372	-	-	-
Clinical instability ≥1	6.83	2.93–15.87	<0.001	5.34	2.17–13.18	<0.001
Microorganisms						
MDR pathogen	2.34	0.86–6.36	0.092	-	-	-
MRSA	3.44	0.76–15.56	0.138	-	-	-
ESBL producing Enterobacteriaceae	2.82	0.63–12.64	0.182	-	-	-
MDR pseudomonas	1.85	0.24–14.44	0.439	-	-	-

*Chronic lung disease includes chronic obstructive pulmonary disease, asthma, bronchiectasis, and interstitial lung disease. †Tube feeding includes nasogastric tube and gastrostomy tube feeding. ‡Nonambulatory status is defined as using a wheelchair for ambulation or being bedridden.

CAP: community-acquired pneumonia; OR: odds ratio; CI: confidence interval; CCI: Charlson comorbidity index; PSI: pneumonia severity index; ICU: intensive care unit; IIAT: inappropriate initial antibiotic therapy; MDR: multidrug-resistant; MRSA: methicillin-resistant *Staphylococcus aureus*; ESBL: extended-spectrum beta-lactamase.

Table 4. Univariable and multivariable analyses of risk factors for pneumonia-unrelated readmissions among patients with CAP

Prognostic factor	Univariable			Multivariable		
	OR	95% CI	p-value	OR	95% CI	p-value
Host related						
Male sex	2.53	1.16–5.51	0.016	-	-	-
Age ≥65 yr	1.84	0.87–3.87	0.105	-	-	-
Comorbidities						
Congestive heart failure	2.01	0.82–4.95	0.137	-	-	-
Cerebrovascular disease	1.37	0.68–2.77	0.377	-	-	-
Dementia	1.41	0.49–4.08	0.531	-	-	-
Chronic lung disease*	3.33	1.80–6.15	<0.001	2.81	1.33–5.95	0.007
Connective tissue disease	0.95	0.93–0.96	1.000	-	-	-
Diabetes mellitus	1.22	0.61–2.46	0.574	-	-	-
Para/hemiplegia	2.01	0.82–4.95	0.137	-	-	-
Chronic kidney disease	4.67	1.93–11.29	0.002	5.70	2.21–14.74	<0.001
Malignancy	2.34	1.09–5.03	0.039	-	-	-
Old myocardial infarction	0.95	0.93–0.96	0.397	-	-	-
Peripheral vascular disease	1.36	0.52–3.55	0.580	-	-	-
Liver disease	0.95	0.93–0.96	0.636	-	-	-
CCI ≥1	8.63	2.07–35.91	<0.001	-	-	-
CCI ≥2	2.81	1.49–5.30	0.001	-	-	-
Medical aid	1.58	0.60–4.14	0.377	-	-	-
Tube feeding†	0.67	0.16–2.84	1.000	-	-	-
Drowsiness/stupor	2.06	0.79–5.56	0.180	-	-	-
Nonambulatory status‡	1.44	0.68–3.06	0.344	-	-	-
Severity score						
CURB-65 ≥3	1.29	0.61–2.73	0.512	-	-	-
PSI class ≥IV	1.43	0.74–2.76	0.288	-	-	-
ICU admission	0.47	0.06–3.47	0.716	-	-	-
Mechanical ventilator	0.43	0.06–3.20	0.719	-	-	-
Treatment						
IIAT	1.04	0.36–3.00	0.790	-	-	-
In-hospital evolution						
Treatment failure	2.99	1.38–6.49	0.009	2.78	1.22–6.34	0.015
Decompensation of comorbidity	3.33	1.80–6.18	<0.001	2.22	1.01–4.67	0.036
Clinical instability ≥1	1.19	0.41–3.43	0.771	-	-	-
Microorganisms						
MDR pathogen	0.45	0.11–1.88	0.422	-	-	-
MRSA	0.95	0.93–0.96	0.621	-	-	-
ESBL producing Enterobacteriaceae	0.75	0.10–5.68	1.000	-	-	-
MDR pseudomonas	1.07	0.14–8.22	1.000	-	-	-

*Chronic lung disease includes chronic obstructive pulmonary disease, asthma, bronchiectasis, and interstitial lung disease. †Tube feeding includes nasogastric tube and gastrostomy tube feeding. ‡Nonambulatory status is defined as using a wheelchair for ambulation or being bedridden.

CAP: community-acquired pneumonia; OR: odds ratio; CI: confidence interval; CCI: Charlson comorbidity index; PSI: pneumonia severity index; ICU: intensive care unit; IIAT: inappropriate initial antibiotic therapy; MDR: multidrug-resistant; MRSA: methicillin-resistant *Staphylococcus aureus*; ESBL: extended-spectrum beta-lactamase.

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lung disease and chronic kidney disease, treatment failure, and decompensation of comorbidities were associated with the pneumonia-unrelated 30-day readmission rate (Table 4).

The likelihood of hospital readmission within 30 days increased with increasing number of risk factors (p<0.001, test for trend) (Figure 2). The 30-day hospital readmission rate after hospital discharge was low (≤3.0%) in patients with no risk factors. In patients with three risk factors, the 30-day hospital readmission rate was considerable (pneumonia-related OR, 42.86; 95% CI, 8.53–215.28; pneumonia-unrelated OR, 35.62; 95% CI, 11.57–109.63).

Discussion

In this study, of the 862 patients hospitalized for CAP, 72 (8.4%) were readmitted within 30 days following hospital discharge. Pneumonia-related and -unrelated causes accounted for 37.5% and 62.5% of the total readmissions, respectively. The risk factors for pneumonia-related readmission (para/hemiplegia, malignancy, PSI class ≥4, and clinical instability ≥1 at hospital discharge) were different from those for pneumonia-unrelated readmission (chronic lung disease, chronic kidney disease, treatment failure, and decompensation of comorbidities). Moreover, the likelihood of hospital readmission increased with increasing number of risk factors.

Several studies performed in the United States and Europe have assessed readmission for pneumonia[13,15-17]. In South Korea, the number of physicians per bed is reportedly associated with readmission of elderly CAP patients[6]. However, this study included only patients >65 years and did not assess demographic or disease-specific factors. To our knowledge, ours is the first Asian study to evaluate risk factors for hospital readmission following discharge of general adult patients (age ≥18 years) hospitalized for CAP.

The all-cause 30-day readmission rate after hospitalization for pneumonia was 8.4%, compared to 7.3%–18.3% in prior works[4,13,18]. In a systematic chart review, the pooled all-cause 30-day readmission rate was 11.6%. Generally, US-based studies and those involving elderly patients (age ≥65 years) show higher rates of all-cause 30-day readmission than non-US–based studies and those involving adults (age ≥18 years)[19]. The all-cause 30-day readmission rate in our study was similar to the values reported by non-US–based studies and those not restricted to elderly patients[13,18]. A prior work involving elderly patients (age >65 years) in South Korea reported a higher (19.1%) all-cause 30-day readmission rate than our finding[6]. Thus, the healthcare environment (including hospital accessibility, financial issues, and medical practices) and age are important determinants of readmission rates.

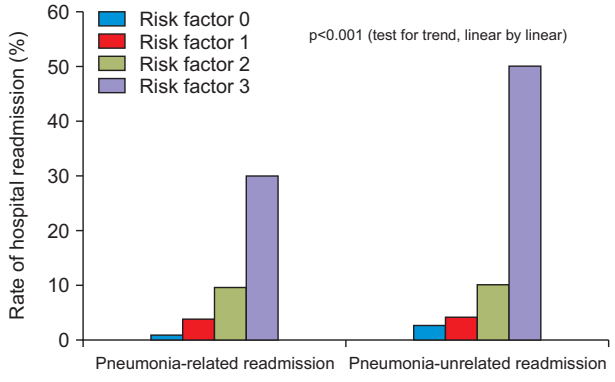

Figure 2. Readmission rate according to number of risk factors.

The leading causes of 30-day readmission in our study were pneumonia (37.5%), pulmonary disease (20.8%), gastrointestinal disease (18.1%), and cardiovascular disease (5.6%). Pneumonia, heart failure/cardiovascular disease, and chronic obstructive pulmonary disease/pulmonary disease are the leading reasons for hospital readmission within 30 days[19]. Interestingly, gastrointestinal causes were the third-most-frequent reasons for hospital readmission. This is higher than in previous reports, possibly because of the effect of the large proportion (63.7%) of high-risk (PSI class ≥4) patients on the incidence of gastrointestinal bleeding and *Clostridium difficile*-associated diarrhea (CDAD) (8 cases/all 13 gastrointestinal causes)[13,15,18]. Indeed, seven of the eight patients (87.5%) who developed gastrointestinal bleeding and CDAD were in the high-risk group (PSI class ≥4).

Para/hemiplegia and malignancy were associated with pneumonia-related readmission. This may be because patients with these comorbidities have decreased performance status and/or immunity. Among patients readmitted for pneumonia-related reasons, 44.4% (12/27) had aspiration pneumonia associated with comorbidities. Indeed, the aspiration risk is reportedly associated with higher rates of readmission and recurrent pneumonia in patients with CAP[20]. Thus, evidence-based interventions, such as angiotensin-converting enzyme inhibitors[21,22], could prevent readmission for recurrent aspiration pneumonia in high-risk patients. Moreover, maintaining good oral hygiene, withholding unnecessary medications, food thickening, sitting upright while eating, head elevation of at least 30°, and swallowing rehabilitation might decrease the risk of aspiration in high-risk patients[23]. Education of patients regarding these interventions before hospital discharge would decrease the pneumonia-related readmission rate.

PSI class ≥IV and clinical instability at hospital discharge were risk factors for pneumonia-related readmission. Unlike previous studies[15,16,18], our findings revealed that PSI class ≥IV is an independent risk factor for pneumonia-related readmission. However, those prior works did not separate pneumonia-related and -unrelated readmissions. We found that a clinical instability score of ≥1 was an independent risk factor for readmission, in accordance with previous reports[13,17]. Discharge at the optimal time (taking into consideration clinical stability)

could prevent pneumonia-related readmission, especially in high-risk patients (PSI class ≥IV). Despite clinical instability, there may be concerns about being discharged from the hospital in this study. However, it is thought that there might have been cases of stable conditions that could be discharged clinically but belonging to clinical instabilities defined in our study. In addition, many patients transferred to secondary hospitals due to comorbidities, so it is thought that there have been cases of step down referral with some clinical instability. Neither the presence of a multidrug-resistant (MDR) pathogen nor IIAT was associated with pneumonia-related readmission.

We found that comorbidities such as chronic lung disease and chronic kidney disease, treatment failure, and decompensation of comorbidities (as in a prior report[13]) were associated with pneumonia-unrelated readmission. This is because pneumonia promotes inflammation and dysregulates the immune response, leading to progression of comorbidities. Also, decompensation of comorbidities during hospitalization doesn't recover well even after being discharged from the hospital, leading to the possibility of rehospitalization. In particular, the proportion of patient with chronic lung disease in our study is high, the acute exacerbation of chronic lung disease caused by pneumonia is thought to have influenced on rehospitalization. Disease severity, presence of an MDR pathogen, and IIAT were not associated with pneumonia-unrelated readmission.

This study had several limitations. First, because it was a retrospective study conducted at a single center, the results cannot be generalized. Second, we did not assess readmissions to other hospitals; we attempted to overcome this limitation by excluding patients who refused outpatient follow-up. However, the number of patients who required readmission could have been underestimated. We believe that a multicenter, prospective study is required in order to assess the causes of readmission in patients with pneumonia. Third, we focused on patient-related factors as determinants of readmission. Physicians' admission decisions and healthcare-system factors are associated with hospital readmissions but were not investigated because of a lack of information. Fourth, the investigation of patients who died within 30 days after discharge was difficult, and there was lack of analysis.

In conclusion, we found that 8.4% of the patients hospitalized for CAP were rehospitalized within 30 days of discharge. This is generally consistent with previous studies involving different populations, regions, and methodologies. Pneumonia-related and -unrelated causes accounted for 37.5% and 62.5%, respectively, of the total readmissions. The risk factors for pneumonia-related and -unrelated readmission were different. Strategies to prevent aspiration and to achieve clinical stability at hospital discharge, especially in patients with PSI class ≥IV, para/hemiplegia, or malignancy could prevent pneumonia-related readmission to hospital. Appropriate management of comorbidities in high-risk patients (i.e., those with chronic lung disease and chronic kidney disease) would reduce the pneumonia-unrelated readmission rate. Therefore, aspiration prevention, discharge at the optimal time, and close monitoring of comorbidities may reduce the frequency of readmission among patients with CAP.

Authors' Contributions

Conceptualization: Ahn JH. Methodology: Jang JG, Ahn JH. Formal analysis: Jang JG, Ahn JH. Writing - original draft preparation: Jang JG. Writing - review and editing: Ahn JH. Approval of final manuscript: all authors.

Conflicts of Interest

No potential conflict of interest relevant to this article was reported.

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