


BMJ Open Is rehabilitation effective in preventing decreased functional status after community-acquired pneumonia in elderly patients? Results from a multicentre, retrospective observational study

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ABSTRACT

Objectives This study was designed to evaluate the effect of rehabilitation in preventing decreased functional status (FS) after community-acquired pneumonia (CAP) in elderly patients.

Design This was a retrospective observational study.

Setting Multicentre study was conducted in two medical facilities from January 2016 to December 2018.

Participants Hospitalised patients with CAP aged over 64 years were enrolled. FS was assessed by the Barthel Index (BI) (range, 0–100, in 5-point increments) at admission and before discharge and graded into three categories: independent, BI 80–100; semidependent, BI 30–75; and dependent, BI 0–25. Multivariable analysis of factors contributing to decreased FS was conducted with two groups: with a decrease of at least one category (decreased group) or without a decrease of category (maintained group).

Primary and secondary outcome measures The primary outcome was the effect of rehabilitation in preventing decreased FS. The secondary outcomes were factors associated with decreased FS.

Results The maintained and decreased groups included 400 and 138 patients, respectively. A high frequency of rehabilitation therapy was observed in the decreased group (189 (47.3%) vs 104 (75.4%); $p < 0.001$). Multivariable analysis showed that the factors affecting FS were aspiration pneumonia, Pneumonia Severity Index (PSI) category V, length of stay and age (OR 2.66, 95% CI 1.58 to 4.49; OR 1.92, 95% CI 1.29 to 3.44; OR 1.05, 95% CI 1.04 to 1.07; and OR 1.05, 95% CI 1.02 to 1.09, respectively). After adjusting for factors contributing to decreased FS, rehabilitation showed a limited effect in preventing decreased FS in 166 matched pairs by McNemar's test ($p = 0.327$).

Conclusions Aspiration and PSI played important roles in reducing FS. The effect of rehabilitation remains unclear in CAP.

Trial registration number UMIN000046362.

BACKGROUND

Pneumonia is causing an increasingly higher proportion of deaths worldwide, with 3.2 million estimated deaths globally each

STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ This is a multicentre retrospective study investigating the effect of rehabilitation in preventing decreased functional status in the elderly after community-acquired pneumonia.
- ⇒ Multivariable analysis was conducted between maintained and decreased functional status groups after pneumonia.
- ⇒ The effect of rehabilitation was identified by propensity score analysis after adjustment with variables determined on multivariable analysis.
- ⇒ Functional status was divided into three categories, not as a continuous variable, which could underestimate the effect of rehabilitation.
- ⇒ The findings may not reflect the effect of rehabilitation on hospital-acquired pneumonia or healthcare-associated pneumonia.

year, exceeding all other infections including tuberculosis and malaria.¹ Community-acquired pneumonia (CAP) is one of the most common medical causes of admission in most healthcare institutions in the USA.² In Japan, pneumonia is the third highest cause of death among elderly patients, continuously increasing with the ageing society.³

Besides the high mortality in elderly patients with CAP, these patients also experience deterioration of functional status (FS), an important component of quality of life in older adults and their caregivers, both during and after treatment.⁴ The prevalence of decreased FS was reported to be 8.6%–20% in CAP and prolongs the length of stay (LOS) in elderly patients.^{5,6} Early rehabilitation therapy might improve activities of daily living (ADLs) during hospitalisation in patients with aspiration pneumonia, but may also increase LOS.⁷

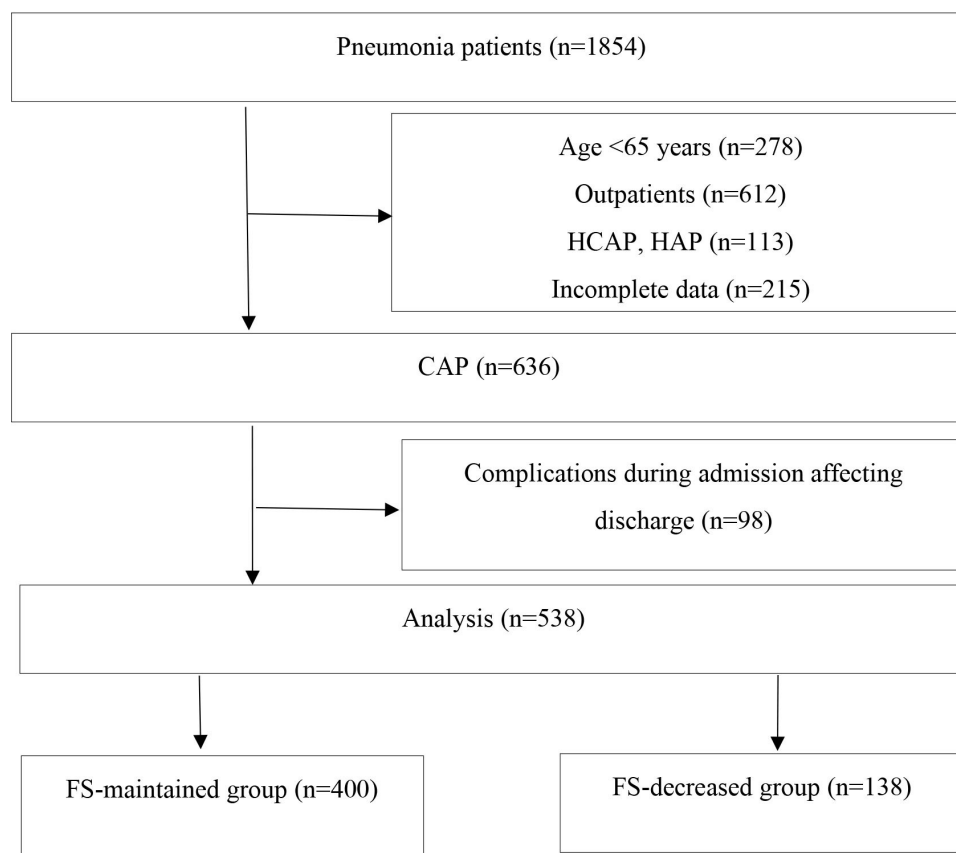


Figure 1 Flow chart of the study. CAP, community-acquired pneumonia; FS, functional status; HAP, hospital-acquired pneumonia; HCAP, healthcare-associated pneumonia.

The clinical and economic burdens resulting from CAP hospitalisation are therefore considerable.

An understanding of the effect of rehabilitation in preventing decreased FS in CAP is important, not least to appraise the cost-effectiveness of rehabilitation. However, various lifestyle-related factors, such as age, gender, ethnicity, marital status, educational attainment, occupation, income, alcohol consumption, smoking, different chronic diseases, physical inactivity, depression, etc, influence FS among older people,⁸ making it difficult to analyse the effect of rehabilitation in preventing decreased FS in these patients. In order to reduce the selection bias of different backgrounds, this study was designed to identify factors related to decreased FS and evaluate the effect of rehabilitation in preventing decreased FS in matched pairs.

METHODS

This was a retrospective observational study of inpatients admitted to a community-based hospital and a teaching hospital in Japan from January 2015 to December 2018.

Definitions

Data on FS, which were documented by nurses daily, were analysed retrospectively by HC and NH. FS was evaluated at admission and before discharge by the Barthel Index (BI)⁹ (range, 0–100, in 5-point increments) of ADL and

was graded into three categories according to the BI: independent, BI 80–100; semidependent, BI 30–75; and dependent, BI 0–25.¹⁰ A decreased FS was considered a reduction in ADL of at least one category. Disorder of consciousness (DOC) was defined as a Glasgow Coma Scale¹¹ score below 15, and for patients with dementia DOC was considered only if their consciousness was worse than their normal status. The key person (representing the main individual supporting the patient during and after admission) was classified as the child, spouse or others. Rehabilitation included any type and intensity of physical rehabilitation programme administered by physicians, physical therapists and occupational therapists. The need for rehabilitation was determined during admission based on the risk of disuse syndrome or aspiration pneumonia. For patients who survived, the sites of the acquisition were classified as home discharge (without nursing), home nursing, facility and transfer to another hospital. Robust diagnostic criteria for aspiration pneumonia are lacking; aspiration pneumonia was defined as an episode of aspiration in the history of present illness or radiographic findings suggesting aspiration pneumonia.

Patient and public involvement

Hospitalised elderly patients with CAP were divided into two groups: the maintained group, without deterioration of FS; and the decreased group, with decreased FS. All

Table 1 Demographic characteristics and outcomes of the maintained and decreased functional status groups

	Total N=538	Maintained group n=400	Decreased group n=138	P value
Age (years)	79 (73–84)	77 (71.3–83)	82 (76–86.3)	<0.001
Sex (male/female)	168/370	131/269	37/101	0.194
BMI (kg/m ²)	19.3 (16.6–22.3)	19.7 (16.7–22.6)	18.6 (16.4–20.9)	0.002
Dementia, n (%)	66 (12.3)	41 (10.3)	25 (18.1)	<0.001
DOC, n (%)	158 (29.4)	91 (22.8)	67 (48.6)	<0.001
Bedsore, n (%)	15 (2.8)	11 (2.8)	4 (2.9)	0.927
Aspiration pneumonia, n (%)	121 (22.5)	59 (14.8)	62 (44.9)	<0.001
In rehabilitation, n (%)	293 (54.5)	189 (47.3)	104 (75.4)	<0.001
CCI, n (%)				0.445
≤1	167 (31.0)	127 (31.8)	40 (29.0)	
2	150 (27.9)	115 (28.8)	35 (25.4)	
≥3	221 (41.1)	158 (39.5)	63 (45.7)	
PSI category, n (%)				<0.001
II	22 (4.1)	21 (5.25)	1 (0.7)	
III	107 (19.9)	90 (22.5)	17 (12.3)	
IV	225 (41.8)	173 (43.3)	52 (37.7)	
V	184 (34.2)	116 (29.0)	68 (49.3)	
ADL before admission, n (%)				<0.001
Independent	367 (68.2)	280 (70.0)	87 (63.0)	
Semidependent	127 (23.6)	76 (19.0)	51 (37.0)	
Dependent	44 (8.2)	44 (11.0)	0 (0.0)	
ADL after admission, n (%)				<0.001
Independent	291 (54.1)	291 (72.8)	0 (0.0)	
Semidependent	121 (22.5)	65 (16.3)	56 (40.6)	
Dependent	126 (23.4)	44 (11.0)	82 (59.4)	
LOS (days)	15 (9–26)	13 (9–19.8)	27 (14–46.3)	<0.001
Survival outcome, n (%)				<0.001
Home	275 (51.1)	271 (67.8)	4 (2.9)	
Home nursing	135 (25.1)	85 (21.3)	50 (36.2)	
Facility	42 (7.8)	20 (5.0)	22 (15.9)	
Hospital	41 (7.6)	16 (4.0)	25 (18.1)	
In-hospital mortality, n (%)	51 (9.2)	8 (2.0)	37 (26.8)	<0.001
Key person, n (%)				0.013
Children	239 (44.5)	163 (40.9)	76 (50.1)	
Spouse	256 (47.7)	204 (51.1)	52 (37.7)	
Others	42 (7.8)	32 (8.0)	10 (7.3)	
Cost (\$)	5231 (3822–7989)	4740 (3542–6488)	8667 (4985–12 901)	<0.001

ADL, activities of daily living; BMI, body mass index; CCI, Charlson Comorbidity Index; DOC, disorder of consciousness; LOS, length of stay; PSI, Pneumonia Severity Index.

enrolled cases had been diagnosed with CAP according to the definitions of the American Thoracic Society/Infectious Diseases Society of America guideline.¹² Patients who fulfilled all of the following inclusion criteria were enrolled in the study: (1) age >64 years; (2) symptoms

compatible with pneumonia (eg, fever, cough, sputum, pleuritic chest pain or dyspnoea); and (3) appearance of new pulmonary infiltrates consistent with pneumonia on chest X-ray or CT. To ensure that all eligible cases were enrolled, the study investigators screened the hospital

Table 2 Multivariable analyses of factors affecting decreased functional status

	OR	95% CI		P value
		Lower limit	Upper limit	
Aspiration pneumonia	2.66	1.58	4.49	<0.001
PSI category V	1.92	1.29	3.44	0.010
LOS	1.05	1.04	1.07	<0.001
Age	1.05	1.02	1.09	0.001

LOS, length of stay; PSI, Pneumonia Severity Index.

database for International Classification of Diseases, 10th Revision codes (J13–18, J69) and reviewed hospital medical records. Repeated episodes of pneumonia in the same patient within 2 weeks were regarded as a single episode.

Data collection was performed from records in the database. There was no increased burden on patients in this study. Results were disseminated alongside increasing awareness of timely caring for patients with CAP.

Exclusion criteria

Cases of healthcare-associated pneumonia (HCAP) and hospital-acquired pneumonia (HAP) were excluded.¹³ Because FS was usually semidependent or dependent in these patients, it was difficult to improve PS of one category or more after rehabilitation. Cases with complications that occurred during admission (myocardial infarction, femoral fracture, cerebral infarction, etc) that would have affected FS were also excluded.

Outcomes

The primary outcome was the effect of rehabilitation in preventing decreased FS. Demographic information, vital signs, including DOC and body mass index (BMI), laboratory values, and comorbidities were collected on admission. Comorbidities were identified according to the Charlson Comorbidity Index (CCI).¹⁴ The Pneumonia

Severity Index (PSI)¹⁵ score was calculated based on data obtained at the time of admission. Information regarding the key person was confirmed soon after admission. Information about acquisitions for survivors was also collected and all patients who died were considered in-hospital deaths. Information on medical costs was collected at discharge.

Statistical analyses

The results are presented as numbers and percentages or median and IQR unless otherwise indicated. Groups were compared using Wilcoxon rank-sum tests. In order to evaluate the effect of rehabilitation on FS, risk factors for decreased FS were determined using stepwise regression analysis. Confounding variables of decreased FS, age, sex, BMI, aspiration, dementia, DOC, undergoing rehabilitation, preadmission ADL, PSI, CCI and LOS were chosen as candidates with p values below 0.2 on univariable analysis. Using the model of the minimum corrected Akaike's information criterion in the backward direction, the final variables were determined. The effect of rehabilitation was evaluated by propensity score analysis by adjustment with variables determined on multivariable analysis for standardised differences of all matching factors to be less than 0.25 in matched pairs.¹⁶ McNemar's test was performed to evaluate the effect of rehabilitation in preventing decreased FS in matched pairs. In all instances, two-tailed values of p<0.05 were considered significant. Data analysis was performed using JMP software (V.15.0; SAS Institute, Cary, North Carolina).

RESULTS

A total of 1854 patients diagnosed with pneumonia were identified. Of these, the following were excluded: 278 due to age <65 years, 612 due to outpatient treatment, 113 due to HCAP or HAP, and 215 due to incomplete data such as PSI, BI, etc. Of the 636 elderly patients with CAP, treatment was prolonged in 98 patients due to complications, even if pneumonia had resolved. The top three complications were heart failure, lumbar compression fracture

Table 3 Detailed information of cases matched by propensity score

	Before matching			After matching			Standardised difference
	In rehabilitation		P value	In rehabilitation			
	Yes	No		Yes	No		
	n=245	n=292		n=166	n=166		
Aspiration, n (%)	97 (33.1)	24 (9.8)	<0.001	27 (16.3)	23 (13.9)	0.539	0.19
PSI category V, n (%)	100 (34.1)	84 (34.3)	0.98	55 (33.1)	56 (33.7)	0.907	0.11
LOS (days)	19	11	<0.001	14	14	0.835	0.04
Age (years)	80	78	<0.001	78	79	0.767	0.07
BMI (kg/m ²)	18.8	19.7	<0.001	19.9	18.6	0.934	0.13
DOC, n (%)	100 (34.1)	58 (23.7)	0.008	46 (27.1)	45 (27.7)	0.727	0.11
BMI, body mass index; DOC, disorder of consciousness; LOS, length of stay; PSI, Pneumonia Severity Index.							

BMI, body mass index; DOC, disorder of consciousness; LOS, length of stay; PSI, Pneumonia Severity Index.

Table 4 Effect of rehabilitation in elderly patients with community-acquired pneumonia

		With rehabilitation		Total
		Decreased	Maintained	
Without rehabilitation	Decreased	7	19	26
	Maintained	26	114	140
Total		33	133	166
P value		0.327		

and femoral fracture in 39 (39.8%), 19 (19.4%) and 11 (11.2%) patients, respectively (online supplemental table S1). The remaining 538 cases were included in the study, including 400 patients in the maintained group and 138 patients in the decreased group (figure 1).

The participants were 370 men (68.8%) and 168 women (31.2%), with a median age of 79 years (73 and 84 years, first and third quartile, respectively). The background characteristics of these patients are summarised in table 1. Sex, bedsores and CCI were not significantly different between the groups. Patients in the decreased group were older, with higher rates of DOC and aspiration and higher PSI categories. Patients in the decreased group had longer LOS (13 days vs 27 days, respectively; $p<0.001$). Accordingly, a higher hospitalisation cost was observed in the decreased group (\$4740 vs \$8667, respectively; $p<0.001$). The decreased group had a higher frequency of rehabilitation during hospitalisation than the maintained group (189 (47.3%) vs 104 (75.4%), respectively; $p<0.001$). A total of 96 patients with Chronic Obstructive Pulmonary Disease (COPD) were included in this study. Pulmonary rehabilitation was conducted in patients with respiratory failure by request of their attending physician, and only 12 patients with continuing respiratory failure were carried out pulmonary rehabilitation in this study by practising mainly pursed-lips breathing. The decreased group had higher frequencies of transfer to a nursing home or another facility or hospital ($p<0.001$, overall) and higher in-hospital mortality (8 (2.0%) vs 37 (36.8%), respectively; $p<0.001$). The top three causative micro-organisms were *Streptococcus pneumoniae*, *Klebsiella pneumoniae* and *Staphylococcus aureus* in 71 (13.2%), 43 (8.0%) and 38 (7.1%) cases, respectively (online supplemental table S2). There were no statistical differences between the two groups.

Multivariable analyses of factors contributing to decreased FS are shown in table 2. Compared with the maintained group, the ORs for LOS, aspiration, age and PSI category V (refer IV+III+II) were 1.05 (95% CI 1.04 to 1.07), 2.66 (95% CI 1.58 to 4.49), 1.05 (95% CI 1.02 to 1.09) and 1.92 (95% CI 1.29 to 3.44), respectively. DOC, BMI and undergoing rehabilitation were not significantly different.

In order to check the effect of rehabilitation in preventing decreased FS, 166 cases were matched after propensity score analysis using variables identified on

multivariate analysis (table 3). Age, BMI, aspiration, DOC, LOS and PSI category V showed no significant differences. For the matched cases, McNemar's test was performed and showed no significant differences in preventing decreased FS between the two groups ($p=0.327$; table 4).

Multiple logistic regression analysis of mortality was conducted between survived and non-survived groups. PSI score and FS at admission were independent factors for mortality. The ORs for PSI score and FS at admission were 131.2 (95% CI 21.2 to 812.1, $p<0.01$) and 5.3 (95% CI 2.2 to 12.6, $p<0.01$) (online supplemental table S3). Multiple linear regression analysis was also conducted to identify the risk factors for patients with CAP above mean hospitalisation expenses, revealing aspiration pneumonia and BMI were independent risk factors (online supplemental table S4). The ORs were 2.06 (95% CI 1.16 to 3.66, $p=0.01$) and 4.8 (95% CI 1.05 to 22.3, $p=0.04$) for aspiration pneumonia and BMI.

DISCUSSION

In this retrospective cohort study, prolonged LOS was observed in the decreased FS group. After multivariable regression analysis, aspiration pneumonia, PSI category V, LOS and age were identified as independent factors contributing to decreased FS. There were 138 (25.7%) elderly patients with CAP who showed decreased FS in this study, which was higher than in previous studies.^{5 6} On propensity score analysis, after adjusting for age, BMI, aspiration pneumonia, DOC, LOS and PSI, rehabilitation showed a limited effect in preventing decreased FS in elderly patients with CAP.

There were other factors affecting decreased FS. Age-associated alterations not only decrease innate and adaptive immune responses but also involve structural and functional deteriorations of most physiological systems, which may negatively impact the ability of the individual to carry out ADL.¹⁷ Ageing is a major risk factor for the development of virtually every lung disease, with increased morbidity and mortality, whereas morbidities and mortalities from other prevalent diseases have decreased or remained stable.¹⁸

In the process of ageing, aspiration pneumonia, a subclass of CAP, is an increasingly significant problem in elderly persons and it is expected to contribute increasingly to mortality and morbidity in the elderly population over the coming decades.¹⁹ Diagnosing aspiration pneumonia has been notoriously problematic because there have not been any established criteria for its diagnosis. Aspiration pneumonia is often diagnosed clinically, relying on history and physical examination. Aspiration pneumonia accounts for 7%–24% of CAP cases.²⁰ The rate of aspiration in patients was 22.5% (overall) and up to 44.9% in the decreased group. Aspiration independently increased the risk of in-hospital mortality²¹ and was also an independent factor related to decreased FS.

The PSI is considered the best predictor of mortality in CAP.^{15 22} Most patients who die from pneumonia

are elderly, with multiple comorbidities and significant limitations in care put in place at or during admission. Surviving patients face the additional problem of decreased FS. According to the present study, FS tended to easily decrease in severe pneumonia. Decreased FS and LOS are important risk factors for unplanned rehospitalisation.²³ A prolonged LOS would result in a higher hospitalisation cost. Aspiration pneumonia and low BMI were independent factors. The average medical cost for the decreased group was almost double that of the maintained group. In addition to finding an effective method of rehabilitation, discharge planning might be necessary to decrease hospitalisation costs. Early discharge planning might be useful in reducing LOS in patients with pneumonia.²⁴

The effects of rehabilitation have been evaluated from various aspects, but there was no definite conclusion. Some studies showed that early rehabilitation reduced LOS^{25 26} in pneumonia, but another study showed that it would prolong LOS.⁷ The effects of rehabilitation on mortality and readmission rates were also unclear.^{27 28} The present study showed that rehabilitation had a limited effect in preventing decreased FS in elderly patients with CAP. This does not mean that rehabilitation is useless in CAP. Further research is warranted to find a more cost-effective approach to rehabilitation with adjustment for patient background and hospital characteristics.

There were no differences in causative micro-organisms between the two groups of different FS. The most frequent causative micro-organism was *S. pneumoniae*. The multivariable analysis showed PSI score and FS at admission were independent factors contributing to hospital mortality, which was coordinated with previous studies.^{29 30}

Limitations

Some limitations to this study need to be considered when interpreting the results. First, this study was limited to two medical facilities. Second, only patients with CAP were included, and FS in HCAP or HAP is also important in elderly patients but remains unclear. Third, due to lack of information about cognitive function, a tool such as the Functional Independence Measure³¹ was not applicable. Fourth, FS was divided into three categories, whereas continuous variables might be more informative. Fifth, there were other factors such as exercise, social issues and economic situation that could affect FS other than rehabilitation, but they were not included in the present study due to lack of information about them on the medical records. Six, PSI was evaluated on admission, not the most severe condition during admission, which might be underestimated.

CONCLUSIONS

Aspiration pneumonia and PSI category V played important role in decreased FS in pneumonia. The effect of rehabilitation is still unclear in CAP and further

research is warranted to analyse the cost-effectiveness of rehabilitation.

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Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Obtained.

Ethics approval This study involves human participants and was approved by the institutional review boards of Yokohama City University Hospital and Kanto Rosai Hospital (reference numbers B190600008 and KR2018-29, respectively) and conformed to the provisions of the Declaration of Helsinki (as revised in Brazil in 2013).

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Is rehabilitation effective in preventing decreased functional status after community-acquired pneumonia in elderly patients – result from a multicenter retrospective observational study

Running title: Functional status after pneumonia

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Supplementary Tables

Table S1 Detail information of complications in excluded patients

Complications	No. patients	Frequency
heart failure	39	39.8%
Lumbar compression fracture	19	19.4%
femoral fracture	11	11.2%
acute myocardial infarction	6	6.1%
cerebral infarction	5	5.1%
Others (tumors, et.al.)	18	18.4%

Table S2. Distribution of the causative microorganisms in patients with maintained and decreased group from sputum and blood cultures.

Microorganisms	Total	Maintained group	Decreased group
<i>Streptococcus pneumoniae</i>	71	58	13
<i>Klebsiella pneumonia</i>	43	29	14
<i>Staphylococcus aureus</i>	38	28	10
<i>Pseudomonas aerogenes</i>	27	20	7
<i>Escherichia coli</i>	19	13	6
<i>Haemophilus influenzae</i>	19	12	7
<i>Moraxella Branhamel</i>	13	9	4
<i>Klebsiella oxytoca</i>	9	7	2
<i>Stenotrophomonas</i>	8	7	1
<i>Raoultella planticola</i>	7	6	1
<i>Streptococcus agalactiae</i>	6	5	1
<i>Enterobacter aerogenes</i>	5	3	2
<i>Enterobacter cloacae</i>	4	3	1
<i>Pseudomonas fluorescens</i>	4	2	2
normal flora	222	168	54
Others	6	4	2
Mixed	11	8	3
Not tested	26	18	8

Table S3 Multivariable analysis of risk factors for mortality in CAP

Risk factors	Mortality			
	OR	95%CI		p value
PSI score	131.2	21.2	812.1	<0.01
FS at admission	5.3	2.2	12.6	<0.01
BMI	0.09	0.01	1.58	0.09
Age	1.01	0.98	1.06	0.38

CAP, community acquired pneumonia; PSI, Pneumonia Severity Index; FS: functional status; BMI, body mass index; OR, odds ratio; CI: confidence interval

Table S4 Multivariable analysis of risk factor for CAP patients above mean hospitalization expenses

Risk factor	High cost			
	OR	95%CI		p value
Aspiration pneumonia	2.06	1.16	3.36	0.01
BMI	4.83	1.05	22.3	0.04
PSI Score	0.29	0.07	1.14	0.07

CAP, community acquired pneumonia; BMI, body mass index; PSI, Pneumonia Severity Index; OR, odds ratio; CI: confidence interval