■ Original Article ■

Demographic Changes in Intensive Care Units in Korea over the Last Decade and Outcomes of Elderly Patients: A Single-Center Retrospective Study

Jeong Uk Lim, Jongmin Lee, Jick Hwan Ha, Hyeon Hui Kang, Sang Haak Lee, and Hwa Sik Moon

Division of Pulmonary, Critical Care and Sleep Medicine, Department of Internal Medicine, St. Paul's Hospital, College of Medicine, The Catholic University of Korea, Seoul, Korea

Background: Aging is a significant issue worldwide, and Korea is one of the most rapidly aging countries. Along with the demographic transition, the age structure of intensive care unit (ICU) patients changes as well.
Methods: The aim of this study was to analyze the change in age distribution of the ICU patients over the last 10 years and its effect on clinical outcomes. Single-center, retrospective analysis of all patients aged ≥18 years admitted to either the medical or surgical ICU at St. Paul's Hospital, The Catholic University of Korea, between January 2005 and December 2014 was conducted. For clinical outcome, in-hospital mortality, duration of ICU stay, and hospital stay were analyzed. Cost analysis was performed to show the economic burden of each age strata.
Results: A total of 10,366 ICU patients were admitted to the chosen ICUs during the study period. The proportion of elderly patients aged ≥65 years increased from 47.9% in 2005 to 63.7% in 2014, and the proportion of the very elderly patients aged ≥80 years increased from 12.8% to 20.7%. However, this increased proportion of elderly patients did not lead to increased in-hospital mortality. The percent of ICU treatment days attributable to elderly patients increased from 51.1% in year 2005 to 64.0% in 2014. The elderly ICU patients were associated with higher in-hospital mortality compared to younger age groups.
Conclusions: The proportion of elderly patients admitted to ICUs increased over the last decade. However, overall in-hospital mortality has not increased during the same period.

Key Words: age distribution; aged; intensive care units; mortality.

Introduction

Aging of the population is a significant issue worldwide, especially in developed countries. The Organization for Economic Cooperation and Development (OECD) report in 2006 showed that the number of people aged 65 years or older will double by the year 2050 [1]. Compared to neighboring East Asian countries, the aging rate of the population in Korea is rapid [2]. According to a report by the Korea Statistical Office, the proportion of people aged 65 years or above surpassed 11.7% of the whole population in the year 2015, and is expected to account for 40% of the national population in 2050. This increase in the percentage of elderly people is a consequence of low birth rate in the past 2 decades, increased life expectancy, and high birth rates during the 1950s and 1960s after the Korean War [3].

Along with an aging population, hospitalization for the elderly population will increase, and intensive care units (ICUs) will face increased admissions and demand by older patients. Elderly patients comprise a substantial proportion of ICU patients and are responsible for higher healthcare costs and longer ICU durations compared to relatively younger patients [4,5]. In Korea, hospital costs and duration of hospital stay also increase with patient age [3].

The percent of elderly ICU patients varies among nations, with values ranging from 3.0% [6] to 13.4% [7]. A study in France involving 75,000 ICU admissions reported that very elderly patients accounted for about 9.6% of the total admissions [8]. Many studies, mostly in developed nations, reported increased mean age of patients admitted to ICUs and increased percentage of ICU admissions attributable to elderly patients. Bagshaw et al. [9] analyzed ICU patients in Australia and New Zealand and showed that the proportion of ICU patients aged 80 years or more has increased, and that in-hospital mortality increased with patient age. Reinikainen et al. [10] reported that the proportion of elderly patients increased in a Finnish ICU, and that the hospital mortality rate increased with increasing age. Other large prospective studies have also reported that older age was associated with higher mortality [11-14].

The demographic changes in ICU patients should also be studied, with a focus on resource utilization. Adhikari et al. [15] suggested that the burden of critical care increases as the population ages, and other studies have suggested that the aging population is strongly associated with more medical resources. A study by Teno et al. [16] showed that ICU use for elderly Medicare beneficiaries has increased during the last decade. To the best of our knowledge, no study evaluating the change in proportions of age groups of patients admitted to ICUs has been reported in Korea.

The aim of this study is to evaluate the demographic changes of recent ICU patients in Korea, and to determine if clinical outcomes such as in-hospital mortality of ICU patients, length of ICU stay, and hospital stay have changed.

Materials and Methods

1) Study design

The present study is a retrospective analysis of electronic data of ICU patients from a single center. The patients admitted to either the medical or surgical ICU of St. Paul's Hospital, The Catholic University of Korea, from January 2005 to December 2014 were analyzed. The medical and surgical ICUs have 13 and 11 beds, respectively, and are equipped with necessary equipment for the treatment and monitoring of patients on mechanical ventilation and/or vasopressor therapy. Patient age, sex, duration of hospital stay, duration of ICU stay, in-hospital mortality, and readmission to ICU within the same hospital admission period were retrospectively collected. This study was reviewed and approved by the institutional review board of St. Paul's Hospital, College of Medicine, The Catholic University of Korea (No. PC-16OISI0002).

2) Outcome measures

The proportion of total admissions of patients aged ≥65 and ≥80 years were described annually and cumulatively. The number of admissions of age groups of <50, 50–64, 65–79, and ≥80 years were compared annually. The mean age of the overall ICU patients was also evaluated each year.

For clinical outcome measures, in-hospital mortality, length of stay in the hospital, and length of stay in the ICU were evaluated annually. The ICU readmission rate, defined as the number of patients readmitted to the ICU during the same hospital admission period, was assessed annually as well.

3) Inclusion criteria

We extracted data from our hospital electronic medical record on ICU admissions attributable to patients aged at least 18 years. Patients were admitted for medical reasons, elective surgery, or emergency surgery between January 1, 2005 and December 31, 2014. We excluded the admissions to the ICU for observation after coronary angiography due to a sudden increase in coronary angi-
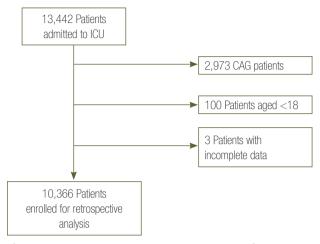
Figure 1. Patients included in the study analysis. ICU: intensive care unit; CAG: coronary angiography.

ography cases after 2012 and possible bias on clinical outcomes of overall ICU patients (Figure 1). In case of multiple admissions by the same patient, admissions other than first admission were excluded.

4) Definition of elderly patients

Upon analysis of past literature concerning the ICU and elderly patients [17,18], we defined elderly patients as those aged 65 years or older. Patients older than 80 years were defined as the very elderly according to previous studies [9,19].

5) Statistical analysis

Descriptive statistics included mean and standard deviation values except when stated otherwise. To see if there was a linear association between study year and age group, both of which are categorical variables, we performed the modified chi-square test and linear by linear association. When the P-value was less than the significance level, 0.05, linear association was counted as valid. Second, we analyzed if each demographic showed any increasing or decreasing trend with time, using a nonparametric method, Mann-Kendall trend analysis. To verify any differences in demographic or clinical data of the four age groups, we performed analysis of variance. Lastly, in order to evaluate the associations between decreasing in-hospital mortality and vasopressors, intubation, and op-

erations, we performed simple linear regression.

6) Total cost per person

Total costs per person during hospital admission were evaluated based on insurance data. All costs are presented in Korean won (KRW).

7) Diagnosis at admission to ICU

The ICU patients with diagnoses associated with ICU mortality were classified into 10 subcategories. Diagnoses were sorted according to main 10th revision of the International Statistical Classification of Diseases (ICD-10) codes of the patients. Regardless of organs involved, patients were classified into the neoplasm category if they were coded with ICD-10 code related to malignant cancer. Patients with A418 or A419 ICD-10 codes were classified into the sepsis category.

8) Operation

The operations undergone be patients admitted to the ICU included surgeries under general anesthesia, regional anesthesia, and local anesthesia. The patients who received operations were classified into five categories (abdominal, thoracic, neurosurgery, orthopedic, and others).

9) Treatment days attributable to elderly patients

We obtained the total number of ICU treatment days and the number attributable to the elderly by summing the days of individual admissions by elderly patients. Percentages of total treatment days attributable to elderly patients were calculated as the sum of treatment days for all elderly patients divided by the sum of treatment days for patients of all age groups.
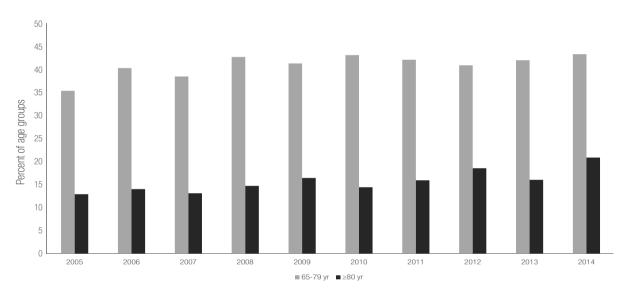
Results

During the 10-year period, 10,366 ICU patients were included in the analysis set constructed from the electronic database of St. Paul's Hospital. During the 10 years, the absolute number and the proportion of patients aged ≥65
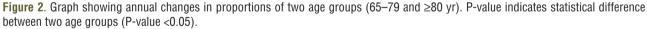
Table 1. Annual percentages of the four different age groups of intensive care unit patients

Year	<50 yr	50–64 yr	65–79 yr	≥80 yr
2005	248 (22.7)	320 (29.3)	383 (35.1)	140 (12.8)
2006	230 (19.9)	303 (26.2)	462 (40.0)	160 (13.9)
2007	223 (20.9)	297 (27.9)	407 (38.2)	138 (13.0)
2008	191 (18.6)	250 (24.4)	435 (42.4)	150 (14.6)
2009	173 (17.9)	241 (24.9)	397 (41.0)	158 (16.3)
2010	194 (17.4)	285 (25.5)	479 (42.8)	160 (14.3)
2011	165 (15.3)	293 (27.1)	451 (41.8)	171 (15.8)
2012	162 (15.1)	278 (25.9)	435 (40.6)	197 (18.4)
2013	111 (12.1)	277 (30.2)	382 (41.7)	146 (15.9)
2014	95 (10.9)	222 (25.4)	376 (43.0)	181 (20.7)
P-value			<0.0001[a]	

Value are presented as number (%).
[a]Result of modified chi-square test for linear by linear association.

Figure 2. Graph showing annual changes in proportions of two age groups (65–79 and ≥80 yr). P-value indicates statistical difference between two age groups (P-value <0.05).

years admitted to the ICU significantly increased annually. The proportion of patients aged 65 years or older increased from 47.9% in 2005 to 63.7% in 2014 (Table 1). The cumulative proportion of patients aged ≥80 years admitted during the study period was 15.4% (n = 1,601) (Table 1, Figure 2).

1) In-hospital mortality

In-hospital mortality of overall patients was 12.1% in 2005, but decreased to 9.6% in 2014 (P = 0.004). For elderly patients, in-hospital mortality also significantly decreased from 16.7% to 10.6% (P = 0.0042) (Table 2). Over the 10 years, in-hospital mortality increased with age group; 6.9% in patients <50 years and 19.1% in patients aged ≥80 years [4,9]. The rate of readmission to the ICU in the same admission period showed a significant difference between age groups (P = 0.0298) (Table 3).

2) Diagnosis at admission

The percentage of patients with respiratory diagnoses

Table 2. Patients characteristics by year

Variable	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	P-value[a]
Patient	1,091	1,155	1,065	1,026	969	1,118	1,080	1,072	916	874	0.0491
Mean age (yr)	61.8 ± 15.6	63.3 ± 15.5	62.5 ± 15.4	64.1 ± 15.1	64.6 ± 15.0	64.3 ± 15.0	64.9 ± 15.3	65.8 ± 14.8	65.8 ± 14.4	67.7 ± 14.3	0.0014
Female	602 (55.2)	610 (52.8)	550 (51.6)	551 (53.7)	474 (48.9)	577 (51.6)	572 (53.0)	583 (54.4)	492 (53.7)	453 (51.8)	0.1524
ICU days attributable to very elderly	582 (12.51)	761 (17.79)	624 (14.21)	627 (17.79)	587 (15.53)	786 (19.46)	828 (18.64)	816 (19.25)	603 (18.85)	807 (24.66)	0.1524
Hospital days attributable to very elderly	2,707 (13.46)	3,019 (15)	2,661 (13.34)	2,147 (11.91)	2,552 (15.44)	2,714 (14.14)	2,970 (16.15)	3,788 (19.85)	2,812 (18.83)	3,189 (21.96)	0.1524
In-hospital mortality	132 (12.1)	152 (13.2)	133 (12.5)	141 (13.7)	111 (11.5)	130 (11.6)	123 (11.4)	121 (11.3)	87 (9.5)	84 (9.6)	0.0073
In-hospital mortality of elderly patients	64 (16.7)	77 (16.7)	53 (13.0)	61 (14.0)	43 (10.8)	55 (11.5)	51 (11.3)	46 (10.6)	43 (11.3)	40 (10.6)	0.0042
ICU type											
Medical	578 (53.0)	595 (51.5)	618 (58.0)	605 (59.0)	585 (60.4)	660 (59.0)	451 (41.8)	440 (41.0)	333 (36.4)	354 (40.5)	0.0736
Surgical	513 (47.0)	560 (48.5)	447 (42.0)	421 (41.0)	384 (39.6)	458 (41.0)	629 (58.2)	632 (59.0)	583 (63.6)	520 (59.5)	0.3711
ICU readmission rate	106 (9.7)	109 (9.4)	84 (7.9)	91 (8.9)	85 (8.8)	101 (9.0)	80 (7.4)	74 (6.9)	57 (6.2)	65 (7.4)	0.0073
Proportion of surgical patients	150 (13.7)	267 (23.1)	270 (25.4)	359 (35.0)	356 (36.7)	482 (43.1)	488 (45.2)	441 (41.1)	373 (40.7)	326 (37.3)	0.0035

Value are presented as number, mean ± standard deviation, or number (%).

ICU: intensive care unit.

[a]Result of Mann-Kendall trend analysis.

increased with age group. Of all diagnostic categories, the highest proportion of patients in each age groups had a neurologic diagnosis (Table 3).

3) ICU treatment days attributable to elderly patients

The percentage of ICU treatment days attributable to patients aged 65 years or more relative to total treatment days of all age groups increased from 51.1% in 2005 to 64.0% in 2014, and the percent of hospital treatment days increased from 49.1% in 2005 to 59.5% in 2012, followed by a gradual decrease in the next 2 years. For very elderly patients aged 80 years or over, the percent of ICU treatment days increased from 12.5% in 2005 to 24.66% in 2014, and the hospital treatment days increased from 13.5% to 22.0% (Table 2).

4) Dobutamine, norepinephrine, dopamine, and intubation

For patients aged ≥80, 7.7% received dobutamine; 9.7% received norepinephrine; 27.7% received dopamine; and 27.7% were intubated. Compared to other younger age groups, the proportion of patients who received aggressive treatment was higher in the very elderly patients. Use of norepinephrine (P = 0.016) and the proportion of intubated patients (P = 0.01) showed significant differences between the age groups (Table 3).

5) Operations

The proportion of patients who underwent operations was 27% in the patients aged <50 years and 38.2% for patients aged from 65 to 74 years. Nevertheless, the proportion of very elderly patients who received operation decreased to 30.5%. For patients aged 65 years or more, orthopedic surgeries were the second most frequently performed surgeries after abdominal surgeries (Table 3).

Table 3. Patients characteristics and clinical outcomes by age group

Variable	<50 yr (n = 1,792)	50–64 yr (n = 2,766)	65–79 yr (n = 4,207)	≥80 yr (n = 1,601)	P-value
Male	1,097 (61.2)	1,716 (62.0)	2,107 (50.1)	544 (34.0)	<0.0001[a]
ICU type					
Medical	953 (53.2)	1349 (48.8)	2037 (48.4)	880 (55.0)	0.9372[a]
Surgical	839 (46.8)	1417 (51.2)	2170 (51.6)	721 (45.0)	0.823[a]
Age (yr)	39.7 ± 7.9	57.4 ± 4.4	71.8 ± 4.1	84.6 ± 3.9	-
Median duration of ICU stay (d)	1 ± 5.7	2 ± 6.5	2 ± 10.4	2 ± 7.2	<0.0001[b]
Median duration of hospital stay (d)	9 ± 25.5	12 ± 18.8	15 ± 18.2	14 ± 18.0	<0.0001[b]
In-hospital mortality	124 (6.9)	251 (9.1)	533 (12.7)	306 (19.1)	<0.0001[a]
Intubation	181 (10.1)	348 (12.6)	662 (15.7)	316 (19.7)	<0.0001[a]
Norepinephrine	75 (4.2)	171 (6.2)	300 (7.1)	156 (9.7)	<0.0001[a]
Dopamine	330 (18.4)	613 (22.2)	1106 (26.3)	444 (27.7)	<0.0001[a]
Dobutamine	106 (5.9)	188 (6.8)	305 (7.2)	123 (7.7)	0.0188[a]
ICU readmission rate	138 (7.7)	227 (8.2)	329 (7.8)	158 (9.9)	0.0298[a]
Total cost per person (KRW)	18,213,069 ± 9,498,514	9,098,337 ± 2,253,776	4,324,299 ± 1,815,562	1,632,010 ± 994,939	<0.001[a]
Diagnosis at ICU admission					0.001[a]
Cardiovascular	156 (8.7)	266 (9.6)	368 (8.7)	152 (9.5)	
Respiratory	96 (5.4)	161 (5.8)	367 (8.7)	205 (12.8)	
Gastrointestinal	167 (9.3)	203 (7.3)	246 (5.8)	101 (6.3)	
Hepatobiliary	171 (9.5)	230 (8.3)	207 (4.9)	83 (5.2)	
Renal	37 (2.1)	74 (2.7)	117 (2.8)	49 (3.1)	
Neurologic	253 (14.1)	511 (18.5)	636 (15.1)	207 (12.9)	
Neoplasm	142 (7.9)	391 (14.1)	551 (13.1)	111 (6.9)	
Sepsis	7 (0.4)	14 (0.5)	33 (0.8)	14 (0.9)	
Metabolic	49 (2.7)	92 (3.3)	132 (3.1)	36 (2.2)	
Operation	483 (27.0)	935 (33.8)	1,605 (38.2)	489 (30.5)	<0.001[a]
Abdominal	159 (32.9)	314 (33.5)	471 (29.3)	111 (22.7)	
Thoracic	54 (11.2)	85 (9.1)	62 (3.9)	14 (2.9)	
Neurosurgery	120 (24.8)	259 (27.7)	218 (13.6)	50 (10.2)	
Orthopedic	53 (11.0)	177 (18.9)	666 (41.5)	269 (55.1)	
Others	17 (3.5)	20 (2.1)	39 (2.4)	7 (1.4)	

Value are presented as number (%) or mean ± standard deviation.
ICU: intensive care unit; KRW, Korean won.
[a]Result of analysis of variance; [b]Result of Kruskal-Wallis test.

6) Total cost per person

Table 4 shows that the total cost per person in overall patients, elderly patients, and very elderly patients increased annually. Medical expenses incurred during admission for elderly patients significantly increased from 3,078,981 KRW in 2005 to 5,552,785 KRW in 2014 (P < 0.001). For the very elderly patients, total cost per person was 1,499,765 KRW in 2005 and significantly increased to 2,103,833 KRW in 2014 (P = 0.0023). The association between increased medical expenses in elderly patients and increase in the number of operations among elderly patients was evaluated by linear regression and showed a significant correlation (P = 0.0113, R^2 = 0.5726). Table 3 shows the total cost per person from each age group,

Table 4. Annual change in medical costs expended

Patient	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	P-value[a]
Overall	6,901,938 ± 5,750,344	6,818,923 ± 6,233,102	7,452,438 ± 6,411,112	7,209,678 ± 6,388,350	7,283,513 ± 6,172,670	7,839,203 ± 7,088,482	8,198,807 ± 8,023,929	7,921,556 ± 7,037,811	8,345,987 ± 7,296,308	8,079,804 ± 8,811,788	0.0042
Elderly	3,078,981 ± 1,432,996	3,324,927 ± 1,444,655	3,669,665 ± 1,578,033	4,030,537 ± 1,768,428	4,083,576 ± 1,484,201	4,479,332 ± 1,674,485	4,708,820 ± 1,695,110	5,040,944 ± 1,693,953	5,390,068 ± 1,757,865	5,552,785 ± 1,809,353	<0.001
Aged ≥80 yr	1,499,765 ± 1,432,996	1,202,370 ± 1,444,655	1,347,979 ± 1,578,033	1,422,915 ± 1,768,428	1,517,404 ± 1,484,201	1,628,645 ± 1,674,485	1,705,852 ± 1,695,110	1,816,514 ± 1,693,953	1,914,464 ± 1,757,865	2,103,833 ± 1,809,353	0.0023

Value are presented as mean ± standard deviation. All the costs are indicated in Korean won.
[a]Result of simple linear regression.

which increased with age group (P = 0.001).

7) Factors that influence in-hospital mortality of elderly patients

Vasopressor, intubation, and operation were evaluated for statistical association with change of in-hospital mortality in elderly patients. Use of at least one kind of vasopressors was not significantly associated with in-hospital mortality of patients aged 65 years or more (P = 0.799, $R^2 = 0.1085$), nor was intubation or surgery (P = 0.4736, $R^2 = 0.1085$ and P = 0.1365, $R^2 = 0.255$, respectively.)

Discussion

In this study, we examined changes in the percentage of ICU admissions by elderly patients in the period 2005 to 2014 in two ICU units of a tertiary university hospital. Over the studied decade, the proportion of elderly patients and the mean age of overall ICU patients increased. To our knowledge, the present study is the first to evaluate changes in the demographic structure and concurrent changes in clinical outcomes of ICU patients in Korea. Furthermore, comparison of clinical outcomes and medical costs by different age groups in ICU has not been reported in Korea.

The Korean population increased from 48,138,007 in 2005 to 50,423,955 in 2014, and the proportion of elderly citizens aged 65 years or older increased from 9.1% to 12.7%. The mean age of the Korean population was 35.5 years in 2005 and increased to 39.8 years in 2014 [2]. The aging of the Korean population was evident when compared to demographic data of other countries [2].

Korea experienced rapid population expansion in the 1960s after the Korean War, and those currently in their 50–60s are usually called "baby boomers." A similar population increase was observed in Europe after World War II [20]. However, the population policy enacted by the Korean government in the 1970s and the change in family value led to a decreased birth rate, thus resulting in an increasing percentage of elderly population.

The present study is a single center study and cannot represent the entire Korean population; however, the number of patients is large enough to show both the demographic change over the last decade and clinical characteristics of elderly ICU patients. The ICU admissions by patients aged ≥80 accounted about 15.4% of overall ICU admissions during the study period. Compared to studies in other countries such as Australia and New Zealand [9], Finland [10], and Saudi Arabia [21], the percentage of ICU admissions attributable to very elderly patients was higher. However, the percentage was lower than the result of an Italian study by Pavoni et al. [22].

With an increasing proportion of elderly patients, in-hospital mortality was expected to increase [9,10]. Unlike our presumption, however, in-hospital mortality decreased during the study period. This result should be approached with consideration of the unique clinical setting. More patients received operations during 2010–2014 compared to earlier years, suggesting increased ICU admission for postoperative observations. Thus, in-hospital mortality, which was expected to increase with the larger proportion of elderly patients, has not increased. However, the decrease in in-hospital mortality of elderly patients was not significantly associated with an increase in operations among the elderly (P = 0.1365, R^2 = 0.255). Nevertheless, in-hospital mortality showed a significant difference between age groups, increasing with age, consistent with previous results [9,11,23].

The very elderly group received the highest proportion of respiratory diagnoses at the time of admission to the ICU. Most of the respiratory diagnoses were acute respiratory distress syndrome or pneumonia, which showed higher proportions among the elderly patients in a previous study [24].

Intensity of ICU treatment [25] and use of medical resources [15,26] are also significant issues. Of all treatment days for the four age groups combined, both the percentages of ICU and hospital treatments days attributable to the very elderly patients increased annually. A significant proportion of the elderly ICU patients received intensive ICU treatment such as inotropics, vaso-

pressors, or intubation, and the proportion was relatively higher than in the younger age groups. Even though our data lacked clinical details including kind and severity of the diseases of the patients, the results showed that vasopressors and airway management were not spared for the elderly patients. The proportion of patients who underwent operation tended to increase with age strata; however, for the very elderly group, the surgery rate was lower compared to the younger elderly group.

In terms of total cost per person, elderly patients seem to incur lower medical expenses compared to younger age groups (Tables 3 and 4); however, the total cost per person in both elderly and very elderly patients gradually increased over the 10 years (Table 4). These results suggest that medical costs of elderly patients will increase in the future. An increase in the number of operations in elderly patients might have influenced the increased medical cost as the association between these two factors was significant (P = 0.0113, R^2 = 0.5726).

With relatively longer ICU stays and increasing total cost per person, our results suggest that the need for medical resources for elderly patients is increasing [15,27,28]. As the proportion of elderly patients increased over the last 10 years, it is likely that medical resources spent on overall ICU patients increased as well [16].

Our study has some limitations. First, it is a single-center retrospective study and does not represent the entire Korean ICU population; it is very likely that the demographic data were influenced by factors unique to our hospital. Coronary angiography cases increased more than two-fold after 2012 and resulted in increased ICU admissions for the sole purpose of observation after the procedure. For that reason, we excluded simple coronary angiography cases. Second, we excluded multiple admissions by same person, using only the first admission in analysis. In this process, admission for more severe illnesses could have been omitted. Third, disease severity scores were not analyzed. Our hospital adopted the electronic Acute Physiology and Chronic Health Evaluation (APACHE) II scoring system prior to ICU admissions in the year 2012, so disease severity data were unreliable

for retrospective analysis.

The present study is the largest single-center, retrospective analysis to show the increased mean age of ICU patients and the percentage attributable to elderly patients in Korea. Despite an increasing proportion of elderly patients admitted to ICUs, overall in-hospital mortality has not increased. We suggest that the rapidly aging national population had a considerable effect on the age structure in our ICU, and the increased proportion of elderly patients is expected to lead to more economic burdens in the ICU. In the future, multicenter studies are needed for a better representation of the Korean elderly ICU population and to evaluate the subtype of elderly patients who will benefit the most from intensive medical care.

ORCID

Jeong Uk Lim   http://orcid.org/0000-0001-8364-2380
Sang Haak Lee   http://orcid.org/0000-0001-6259-7656

References

1. United Nations. World population prospects: the 2006 revision [Internet]. New York (NY): United Nations; 2007 [cited 2017 May 22]. Available from https://www.un.org/esa/population/publications/wpp2006/wpp2006.htm.

2. United Nations, Department of Economic and Social Affairs, Population Division. World mortality 2007 [Internet]. New York (NY): United Nations; 2007 [cited 2017 May 18]. Available from: http://www.unpopulation.org.

3. Statistics Korea. The distribution of the population according to age and medical expenditures by age groups [Internet]. Daejeon: Statistics Korea [cited 2017 May 22]. Available from: http://kostat.go.kr/portal/korea/index.action.

4. Boumendil A, Guidet B. Elderly patients and intensive care medicine. Intensive Care Med 2006;32:965-7.

5. Song X, MacKnight C, Latta R, Mitnitski AB, Rockwood K. Frailty and survival of rural and urban seniors: results from the Canadian study of health and aging. Aging Clin Exp Res 2007;19:145-53.

6. Kaarlola A, Tallgren M, Pettila V. Long-term survival, quality of life, and quality-adjusted life-years among critically ill elderly patients. Crit Care Med 2006;34:2120-6.

7. Somme D, Maillet JM, Gisselbrecht M, Novara A, Ract C, Fagon JY. Critically ill old and the oldest-old patients in intensive care: short- and long-term outcomes. Intensive Care Med 2003;29:2137-43.

8. Boumendil A, Aegerter P, Guidet B; CUB-Rea Network. Treatment intensity and outcome of patients aged 80 and older in intensive care units: a multicenter matched-cohort study. J Am Geriatr Soc 2005;53:88-93.

9. Bagshaw SM, Webb SA, Delaney A, George C, Pilcher D, Hart GK, et al. Very old patients admitted to intensive care in Australia and New Zealand: a multi-centre cohort analysis. Crit Care 2009;13:R45.

10. Reinikainen M, Uusaro A, Niskanen M, Ruokonen E. Intensive care of the elderly in Finland. Acta Anaesthesiol Scand 2007;51:522-9.

11. Knaus WA, Draper EA, Wagner DP, Zimmerman JE. APACHE II: a severity of disease classification system. Crit Care Med 1985;13:818-29.

12. Knaus WA, Wagner DP, Draper EA, Zimmerman JE, Bergner M, Bastos PG, et al. The APACHE III prognostic system: risk prediction of hospital mortality for critically ill hospitalized adults. Chest 1991;100:1619-36.

13. Moreno RP, Metnitz PG, Almeida E, Jordan B, Bauer P, Campos RA, et al. SAPS 3--from evaluation of the patient to evaluation of the intensive care unit. Part 2: development of a prognostic model for hospital mortality at ICU admission. Intensive Care Med 2005;31:1345-55.

14. Le Gall JR, Lemeshow S, Saulnier F. A new Simplified Acute Physiology Score (SAPS II) based on a European/North American multicenter study. JAMA

1993;270:2957-63.

15. Adhikari NK, Fowler RA, Bhagwanjee S, Rubenfeld GD. Critical care and the global burden of critical illness in adults. Lancet 2010;376:1339-46.

16. Teno JM, Gozalo PL, Bynum JP, Leland NE, Miller SC, Morden NE, et al. Change in end-of-life care for Medicare beneficiaries: site of death, place of care, and health care transitions in 2000, 2005, and 2009. JAMA 2013;309:470-7.

17. Conti M, Merlani P, Ricou B. Prognosis and quality of life of elderly patients after intensive care. Swiss Med Wkly 2012;142:w13671.

18. Hennessy D, Juzwishin K, Yergens D, Noseworthy T, Doig C. Outcomes of elderly survivors of intensive care: a review of the literature. Chest 2005;127:1764-74.

19. Haas LE, Karakus A, Holman R, Cihangir S, Reidinga AC, de Keizer NF. Trends in hospital and intensive care admissions in the Netherlands attributable to the very elderly in an ageing population. Crit Care 2015;19:353.

20. Kawakami T, Mizoguchi M, Saito R, Soma Y. Histopathological evidence of small-vessel vasculitis within the skin and lungs associated with interstitial pneumonia in an adult patient with dermatomyositis. Clin Exp Dermatol 2008;33:415-7.

21. Al-Dorzi HM, Tamim HM, Mundekkadan S, Sohail MR, Arabi YM. Characteristics, management and outcomes of critically ill patients who are 80 years and older: a retrospective comparative cohort study. BMC Anesthesiol 2014;14:126.

22. Pavoni V, Gianesello L, Paparella L, Buoninsegni LT, Mori E, Gori G. Outcome and quality of life of elderly critically ill patients: an Italian prospective observational study. Arch Gerontol Geriatr 2012;54:e193-8.

23. Fuchs L, Chronaki CE, Park S, Novack V, Baumfeld Y, Scott D, et al. ICU admission characteristics and mortality rates among elderly and very elderly patients. Intensive Care Med 2012;38:1654-61.

24. Baldo V, Cocchio S, Baldovin T, Buja A, Furlan P, Bertoncello C, et al. A population-based study on the impact of hospitalization for pneumonia in different age groups. BMC Infect Dis 2014;14:485.

25. Lerolle N, Trinquart L, Bornstain C, Tadie JM, Imbert A, Diehl JL, et al. Increased intensity of treatment and decreased mortality in elderly patients in an intensive care unit over a decade. Crit Care Med 2010;38:59-64.

26. Sznajder M, Leleu G, Buonamico G, Auvert B, Aegerter P, Merliere Y, et al. Estimation of direct cost and resource allocation in intensive care: correlation with Omega system. Intensive Care Med 1998;24:582-9.

27. Friedrich JO, Wilson G, Chant C. Long-term outcomes and clinical predictors of hospital mortality in very long stay intensive care unit patients: a cohort study. Crit Care 2006;10:R59.

28. Torres OH, Francia E, Longobardi V, Gich I, Benito S, Ruiz D. Short- and long-term outcomes of older patients in intermediate care units. Intensive Care Med 2006;32:1052-9.