BMJ Open

Analysis of high-intensity care in intensive care units and its cost at the end of life among older people in South Korea between 2016 and 2019: a cross-sectional study of the health insurance review and assessment service national patient sample database

Yunji Lee,[1] Minjeong Jo ,[2] Taehwa Kim,[3] Kyoungsun Yun[4]

To cite: Lee Y, Jo M, Kim T, *et al*. Analysis of high-intensity care in intensive care units and its cost at the end of life among older people in South Korea between 2016 and 2019: a cross-sectional study of the health insurance review and assessment service national patient sample database. *BMJ Open* 2021;**11**:e049711. doi:10.1136/bmjopen-2021-049711

► Prepublication history for this paper is available online. To view these files, please visit the journal online (http://dx.doi.org/10.1136/bmjopen-2021-049711).

Received 02 February 2021
Accepted 12 August 2021

For numbered affiliations see end of article.

Correspondence to
Professor Minjeong Jo;
minjeongjo@catholic.ac.kr

ABSTRACT

Objectives To provide useful information for clinicians and policy makers to prepare guidelines for adequate use of medical resources during end-of-life period by analysing the intensive care use and related costs at the end of life in South Korea.

Design Cross-sectional, retrospective, observational study.

Setting Tertiary hospitals in South Korea.

Participants We analysed claim data and patient information from the Health Insurance Review and Assessment Service national dataset. This dataset included 19 119 older adults aged 65 years or above who received high-intensity care at least once and died in the intensive care unit in South Korea between 2016 and 2019. High-intensity care was defined as one of the following treatments or procedures: cardiopulmonary resuscitation, mechanical ventilation, extra-corporeal membrane oxygenation, haemodialysis, transfusion, chemotherapy and vasopressors.

Primary and secondary outcome measures Usage and cost of high-intensity care.

Results The most commonly used high-intensity care was transfusion (68.9%), mechanical ventilation (50.6%) and haemodialysis (35.7%) during the study period. The annual cost of high-intensity care at the end of life increased steadily from 2016 to 2019. There existed differences by age, gender, length of hospital stays and primary cause of death in use of high-intensity care and associated costs.

Conclusion Findings indicate that invasive and device-dependent high-intensity care is frequently provided at the end of life among older adults, which could potentially place an economic burden on patients and their families. In Korea's ageing society, increased rates of chronic illness are expected to significantly burden those who lack the financial resources to provide end-of-life care. Therefore, guidelines for the use of high-intensity care are required to ensure affordable end-of-life care.

Strengths and limitations of this study

- ► This is the first large-scale analysis to represent the recent status of end-of-life intensive care using the national healthcare data (2016–2019) in South Korea.
- ► This study provides a detailed analysis of the use of high-intensity care at the end of life under the Korean healthcare system, based on the scope of life-sustaining treatments presented in the Act on Hospice and Palliative Care and Decision on Life-Sustaining Treatment for Patients at the End of Life (LST Decision Act).
- ► Cohort data over an extended period of time provide information on changes in the use of high-intensity care and related costs before and after 2018, when the LST Decision Act was enacted in South Korea.
- ► We analysed only the costs incurred by the use of medical services, and did not include non-medical services costs, such as those related to caregiving.

INTRODUCTION

Medical treatment use and associated expenditures have rapidly increased with the prevalence of chronic disease due to an ageing society and lifestyle changes. According to 2018 statistics,[1] the growth rate of medical expenditure in South Korea was 1.3%, which is much higher than that of Organization for Economic Cooperation and Development member countries (0.2%). The trend of increased medical expenses is also appearing in the area of treatment for critical patients nearing death, which poses particular burden on national medical finances.[2] Studies have shown that patients who are on inevitable transition to dying usually receive invasive or

life-prolonging treatments at the end of life.[3 4] End-of-life (EOL) care refers to all healthcare services administered in a distinct timeframe before death; however, it varies between clinical settings, healthcare providers and researchers.[5] Intensive care at the end of life includes admission to an intensive care unit (ICU), cardiopulmonary resuscitation (CPR), mechanical ventilation (MV), dialysis and chemotherapy.[3] It has been reported that terminally ill patients with cancer receive chemotherapy even when their death is imminent in South Korea.[6 7] Although such high-intensity treatments in the final stages of disease may prolong the survival period,[8] it does not necessarily improve the quality of care at the end of life.[9]

High-intensity care in the ICU in the period nearing death accounts for more than 20% of total hospital expenses and more than 50% of hospital deaths.[10] South Korea is one of the world's fastest ageing countries, and it is predicted that adults over 65 years old will comprise approximately 42.5% of the total population by 2065.[11] Considering the correlation between ageing and healthcare expenditures,[12 13] it is necessary to understand the current status of intensive care at the end of life in older people, which can add burden on the healthcare system.

In South Korea, the Act on Hospice and Palliative Care and Decision on Life-Sustaining Treatment for Patients at the End of Life (LST Decision Act) has been implemented since 2018.[14] Under this Act, patients at the terminal stage can express their intentions regarding treatment to their physicians. Due to this legislation, the public has become highly interested in advance care planning (ACP) to improve the quality of care during the terminal phase. The ACP is a process in which patients discuss and make a decision for their future healthcare in a collaborative effort including family members (or surrogates) and healthcare providers.[15] Understanding the current status of intensive care at the end of life can provide preliminary data to select a target population and develop strategies for effective ACP. However, little is known about the extent of such intensive care in South Korea. Therefore, the purpose of this study was to investigate the current status and factors associated with high-intensity care given to older adults before their death in ICUs in South Korea.

METHODS

Data source

This study used data collected from the Health Insurance Review and Assessment (HIRA) database for the period 2016–2019. The HIRA database contains health insurance claims data, which include the cost information of all medical services and prescription drugs that are reimbursed by Korean National Health Insurance (KNHI) and the Medical Aid Programme (MAP). The KNHI covers approximately 97% Koreans, and the MAP covers the remaining 3% Koreans who cannot afford national insurance. The HIRA service, a central office in the Korean Ministry of Health reviews the submitted claims for reimbursement to KNHI and MAP.[16] The HIRA included information on older adults ≥65 years who received high-intensity care at least once and died in the ICU of tertiary hospitals.

Patient and public involvement

There was no direct patient or public involvement in this study.

Study design and population

This study is a cross-sectional, retrospective, observational study based on HIRA database. Database included older adults ≥65 years who received high-intensity care at least once and died in the ICU.

Outcome variables definition

Sample characteristics

The sample characteristics included age, gender, type of health insurance, Charlson Comorbidity Index (CCI), hospital length of stay and primary cause of death. The type of health insurance was divided into KNHI and MAP, which was determined by personal household income.[16] The CCI[17] was categorised into four groups with CCI scores of 0, 1, 2 and ≥3, respectively.[18 19] Hospital length of stay was determined by the period of selected claim data, which was the number of days from the hospitalised date to the expired date. In this study, we extracted the data of subjects with an exacerbation of chronic life-limiting illness requiring to intensive treatment, and not of those subjects who died as a result of acute life-threatening illness. Therefore, the data of subjects with reported chronic diseases related to high mortality among Koreans as the primary causes of death[20] were extracted. Consequently, suicide and accident as causes of death were excluded owing to their inappropriateness for this study. The primary cause of death was classified as follows: malignant neoplasm (C00–C97), heart disease (I00–I09 and I20–I51), pneumonia (J12–J18), cerebrovascular disease (I60–I69), chronic renal failure (N18–N19), liver disease (K70–K76), chronic lower respiratory disease (J40–J47), diabetes mellitus (E10–E14), hypertensive disease (I10–I13), dementia (F00–F03 and G30–G32) and others. The codes for the cause of death correspond to the Korean Standard Classification of Diseases 7th edition (KCD-7).[21] The KCD-7 is the modified version of the International Classification of Diseases 10th Revision (ICD-10).[22] Diseases that did not belong to any category were classified as 'other'.

High-intensity care at the end of life

In this study, the high-intensity EOL care was defined as treatments administered during the last ICU stay before death. Based on the scope of life-sustaining treatments provided in the LST Decision Act in South Korea,[14] high-intensity care at the end of life was defined as receiving at least one of the following treatments or procedures in the ICU: CPR, MV, extra-corporeal membrane oxygenation (ECMO), haemodialysis (HD), transfusion, chemotherapy and vasopressors. The high-intensity care corresponded with the following codes, per HIRA and KNHI[23]: CPR

(KNHI codes M1583–7), MV (M5850–8, M5860), ECMO (O1901–6), HD (O7020 (intermittent haemodialysis) and O7031-4 (continuous renal replacement therapy)), transfusion (X2011–2, X2021–2, X2031–2, X2041–2, X2051–2, X2061–2, X2071–2, X2081–2, X2091–2, X2101–2, X2111–2, X2121–2, X2131–2, X2141–2) and chemotherapy (KK151–6). Vasopressors were identified using the Korean drug and anatomical therapeutic chemical codes.[24] The vasopressors most commonly prescribed in South Korea included the following drugs: dobutamine, dopamine, ephedrine, epinephrine, isoproterenol, milrinone, norepinephrine, phenylephrine and vasopressin.[24 25]

Costs associated with high-intensity care

The total cost of medical care is the sum of the expenses paid by KNHI and individual patient extracted from the data for one claim at the time of death. The cost for high-intensity care was calculated by the total cost for the claim using the procedure codes of high-intensity care (ie, CPR, MV, ECMO, HD, transfusion and chemotherapy) and drug codes for vasopressors during the patient's hospitalisation. The costs for medical care and drugs in Korean won were converted to US$ using the conversion rate of 1200 won/dollar (exchange rate as of 15 September 2020) .

Data analysis

The data were analysed using SAS V.9.4 (SAS Institute). The use of high-intensity care was presented as the number of patients with at least one procedure or drug code. Medical and high-intensity care costs among the different years were compared by one-way analysis of variance followed by post-hoc Scheffé test. Multiple logistic regression analysis was used to examine the association of high-intensity care use with patient-relative characteristics. Among the various types of high-intensity care, vasopressors were excluded from this regression analysis because all patients in the study sample had received vasopressors. Analysis was conducted after integrating hypertensive disease and dementia into heart disease and cerebrovascular disease, respectively, among the primary cause of death. This was because the number of deceased older adults with a hypertensive disease (n=10) or dementia (n=4) as a primary cause of death was very small.

RESULTS

Sample characteristics

Sample characteristic are presented in table 1. The mean age at the death was 76.62 years (SD=6.82), and 57.5% were men. The median CCI score was 0 (IQR=0, 1). Approximately 45% of patients stayed at the hospital more than 11 days, and the mean hospital stay was 13.18 days (SD=12.82). The three most common primary causes of death were malignant neoplasm (n=3784, 19.8%), heart diseases (n=3406, 17.8%) and pneumonia (n=2061, 10.8%).

High-intensity care at the end of life

The annual use of high-intensity care at the end of life is presented in table 2. As seen in the statistics for high-intensity care use over 4 years, transfusion was found to be the most common procedure (68.9%), followed by MV (50.6%), HD (35.7%), CPR (18.3%), chemotherapy (3.0%) and ECMO (1.2%). Between 2016 and 2019, the use of HD, transfusion and chemotherapy gradually increased, while the use of CPR, MV and ECMO decreased.

Sample characteristics significantly related to the likelihood of using at least one form of high-intensity care at the end of life differed depending on the type of high-intensity care (table 3). Advanced age was associated with decreased odds of receiving most types of high-intensity care. Those aged 75 years or older showed statistically significant lower use of high-intensity care than those 65–69 years except for MV. In the case of older adults who were hospitalised for more than 30 days, the odds of receiving a transfusion and chemotherapy was approximately 7 and 9 times higher, respectively, than those hospitalised for fewer than 10 days (AOR (95% CI)=6.95 (5.86 to 8.29) for transfusion, AOR (95% CI)=8.56 (6.43 to 11.51) for chemotherapy). The odds of receiving each form of high-intensity care differed depending on the sample's primary cause of death. Decedents with liver disease had significantly higher odds of receiving a transfusion (AOR (95% CI)=3.05 (2.15 to 4.45)). The odds of receiving ECMO in older adults with heart diseases was more than 11 times higher (AOR (95% CI)=11.78 (8.27 to 17.27)) than that of the reference group.

Costs associated with high-intensity care

The mean total medical cost was $13 566.97 per decedent and the mean total cost associated with high-intensity care was $1084.84 between 2016 and 2019 (figure 1). Both medical and high-intensity care costs consistently increased over the study period. The mean medical and high-intensity care costs in 2018 and 2019 increased significantly compared with those in 2016 and 2017 (table 4). During the same period, the cost of using high-intensity care accounted for 7.9%–8.6% of the total medical cost.

Sample characteristics significantly associated with the high-intensity care cost included the following: age, type of health insurance, hospital length of stay and primary cause of death (table 5). Advanced age was associated with increased costs for high-intensity care use. Patients aged 70 years or older showed statistically significant lower expenditures (β=−0.40 to −0.09, p<0.001) compared with those aged 65–69 years. MAP was associated with the decreased cost (β=−0.05, p=0.039). Samples with a hospital length of stay longer than 11 days were associated with increased costs for high-intensity care use (β=0.34–0.96, p<0.001) compared with decedents who were hospitalised for less than 10 days. The cost of high-intensity care was significantly higher in deaths associated with liver disease (β=0.29, p<0.001) than other groups among the categories of primary cause of death.

Table 1 Demographics of subjects (n=19 119)

Characteristics	Categories	n (%)
Age at death (years)	65–69	3490 (18.3)
	70–74	4060 (21.2)
	75–79	5056 (26.4)
	80–84	4025 (21.1)
	≥85	2488 (13.0)
	M±SD (Min–Max)	76.62±6.82 (65–105)
	Median (IQR)	76 (71–81)
Sex	Male	10 994 (57.5)
	Female	8125 (42.5)
Health insurance	KNHI	17 698 (92.6)
	MAP	1421 (7.4)
CCI (score)	0	12 898 (67.5)
	1	4017 (21.0)
	2	1535 (8.0)
	≥3	669 (3.5)
	M±SD (Min–Max)	0.49±0.83 (0–7)
	Median (IQR)	0 (0–1)
Hospital length of stay (days)	≤10	10 561 (55.2)
	11–20	4402 (23.0)
	21–30	2344 (12.3)
	>30	1812 (9.5)
	M±SD (Min–Max)	13.18±12.82 (1–176)
	Median (IQR)	9 (4–19)
Primary cause of death	Malignant neoplasm	3784 (19.8)
	Heart diseases	3406 (17.8)
	Pneumonia	2061 (10.8)
	Cerebrovascular diseases	1514 (7.9)
	Chronic renal failure	391 (2.0)
	Liver disease	327 (1.7)
	Chronic lower respiratory diseases	180 (0.9)
	Diabetes mellitus	75 (0.4)
	Hypertensive diseases	10 (0.1)
	Dementia	4 (0.0)
	Others	7367 (38.5)

CCI, Charlson Comorbidity Index; KNHI, Korean National Health Insurance; MAP, medical aid programme of Korea.

DISCUSSION

This study is a descriptive cohort study using recent national healthcare data to quantify and characterise factors associated with high-intensity care use and costs at the end of life among older adults. In this study, the mean age at death among the deceased older population was 76.6 years. In a study by Kim *et al*,[26] which investigated the status of intensive care for Korean elderly patients for a period of 1 month before death, those aged 75 years old accounted for approximately 68% (n=4272) of the study subjects. Additionally, the average age range of cancer decedents (n=248 978) who received treatments in EOL settings was 71–76 in a Japanese study.[27] Such findings suggest that a large proportion of the older population over 70 years old are likely to receive high-intensity care in the final stages of their life.

The primary diagnoses at time of death for the sample were malignant neoplasm, heart disease and pneumonia. This is similar to 2019 Korean statistics showing the main causes of death among elderly adults over the age of 65 as malignant neoplasm, heart diseases, pneumonia, cerebrovascular diseases, liver diseases, diabetes mellitus and

Table 2 Annual usage of high-intensity care by type

Type of high-intensity care (n (%))	Total	Year			
		2016 (n=6009)	2017 (n=6163)	2018 (n=6710)	2019 (n=237)
CPR	3504 (18.3)	1066 (17.7)	1010 (16.4)	1391 (20.7)	37 (15.6)
MV	9672 (50.6)	3120 (51.9)	3061 (49.7)	3383 (50.4)	108 (45.6)
ECMO	230 (1.2)	79 (1.3)	73 (1.2)	76 (1.1)	2 (0.8)
HD	6834 (35.7)	2113 (35.2)	2171 (35.2)	2464 (36.7)	86 (36.3)
Transfusion	13 180 (68.9)	4155 (69.1)	4269 (69.3)	4590 (68.4)	166 (70.0)
Chemotherapy	567 (3.0)	165 (2.7)	185 (3.0)	203 (3.0)	14 (5.9)

CPR, cardiopulmonary resuscitation; ECMO, extra-corporeal membrane oxygenation; HD, haemodialysis; MV, mechanical ventilation.

Alzheimers.[28] While average life expectancy has increased globally, quality of life may not yet extend until death. Specifically, the average life expectancy for Koreans was 82.7 years in 2019, but healthy life expectancy was 64.4 years.[29] This suggests that many older people may have to manage chronic disease approximately 15 years or more and potentially face EOL situations where they require intensive care.

The results indicate that a transfusion (68.9%) was the most frequently used treatment among older adults. Baek *et al*[30] reported that approximately 45% of patients received a transfusion during the week before death. Kim *et al*[31] also found that the most commonly prescribed intensive treatment after a completing do-not-resuscitate order was a transfusion. Following transfusion, MV (50.6%) was also one of the main high-intensive care treatments received by older adults. The high use of MV is similar to the results of cohort studies in other countries. Approximately 43%–69% of patients received MV during their terminal hospitalisation in the USA and Taiwan.[4 32–35] Contrary to these findings, patients did not prefer invasive, device-dependent treatments such as MV,[36–38] which suggests that the patient's EOL treatment preference may not be well reflected in the actual treatment decision making. This may be because South Korea is a family-centred country with Confucian values. In such a cultural context, families may feel that they should provide their spouses or older parents with all possible treatments available to fulfil the values of love or filial piety.[39] Additionally, EOL communication in South Korea is commonly avoided between families and clinicians until near the time of the patient's death because of a cultural taboo related to talking about death and dying.[40] Therefore, further study investigating whether the frequent use of high-intensity care reflects the patient's treatment preferences and care goals is warranted.

The findings further indicate that the use of advanced mechanical organ support such as CPR, MV and ECMO decreased during the period 2016–2018, while conventional medical support including chemotherapy and transfusion increased. This differs from the results of an ICU cohort study by Park *et al*,[22] in which the use of conventional medical support decreased but advanced life support increased among adult patients from 2009 to 2014. This difference might be due to the fact that the database used in this study was the most recent data from 2016 to 2019. Moreover, in South Korea, the LST Decision Act[14] has been implemented since 2018. There is insufficient evidence to claim that the Act has directly caused a change in the use of high-intensity care. However, as such social circumstances can affect the perceptions or attitudes of patients, families and clinicians about LST, it will be helpful to facilitate EOL discussions and ACP.

The mean EOL total medical cost was approximately $13 600 per decedent. This cost increased consistently, with high-intensity care costs accounting for approximately 8%–9% of total costs during the study period. Such an increase in medical costs is similar to the findings of a previous cohort study[22] that analysed ICU admissions in South Korea. In an Australian cohort study,[41] the average hospitalisation cost for decedents with cancer during the 6 months before death was $A22 852 (US$18 281). Similarly, the mean total healthcare cost for treatment during the last month before death was $2073 in older patients with liver cancer in Taiwan.[4] It is difficult to directly compare the medical costs between countries due to the different health systems and medical environments in each country, but the costs incurred at the end of life are generally high. Moreover, many cohort studies reporting medical costs, including this study, partially analysed costs with codes for specific treatment or procedure. Given this, patients and their family members may actually have paid much more for medical material, devices and treatments related to high-intensity care.

This study provides additional information on factors related to high-intensity EOL care and costs. The finding that older patients (over 75 years old) were less likely to use high-intensity care is similar to that of other cohort studies.[26 35 41–43] The result that longer hospitalisation stays (more than 11 days) tended to increase the use of high-intensity care such as MV or transfusion and medical costs is similar to that of an Australian study.[41] Additionally, patients with malignant neoplasm, liver disease and chronic renal failure as a primary cause of death were more likely to receive high-intensity care at the end of life, which is supported by a cohort study conducted in

Table 3 Factors associated with use of high-intensity care

Characteristics	Categories	Type of high-intensity care (AOR (95% CI))					
		CPR	MV	ECMO	HD	Transfusion	Chemotherapy
Age at death (years)	65–69 (Ref)						
	70–74	1.01 (0.90 to 1.14)	0.93 (0.85 to 1.02)	0.84 (0.60 to 1.19)	0.92 (0.83 to 1.01)	0.83 (0.75 to 0.93)	0.78 (0.63 to 0.98)
	75–79	0.88 (0.79 to 0.98)	0.92 (0.84 to 1.00)	0.46 (0.32 to 0.66)	0.84 (0.76 to 0.92)	0.76 (0.68 to 0.84)	0.55 (0.43 to 0.70)
	80–84	0.82 (0.73 to 0.92)	0.79 (0.72 to 0.87)	0.21 (0.13 to 0.34)	0.79 (0.72 to 0.87)	0.70 (0.63 to 0.78)	0.30 (0.21 to 0.42)
	≥85	0.71 (0.62 to 0.82)	0.73 (0.66 to 0.82)	0.13 (0.06 to 0.26)	0.56 (0.50 to 0.63)	0.56 (0.50 to 0.63)	0.17 (0.09 to 0.29)
Sex	Male (Ref)						
	Female	0.96 (0.89 to 1.03)	0.94 (0.88 to 0.99)	0.64 (0.47 to 0.85)	1.10 (1.03 to 1.17)	1.34 (1.25 to 1.44)	1.31 (1.09 to 1.57)
Health insurance	KNHI (Ref)						
	MAP	1.02 (0.89 to 1.17)	0.85 (0.77 to 0.96)	0.72 (0.40 to 1.22)	0.87 (0.77 to 0.98)	1.00 (0.88 to 1.13)	0.54 (0.35 to 0.87)
CCI (score)	0 (Ref)						
	1	1.03 (0.94 to 1.13)	0.93 (0.87 to 1.00)	0.93 (0.67 to 1.28)	1.04 (0.96 to 1.12)	1.04 (0.96 to 1.13)	1.00 (0.80 to 1.23)
	2	1.08 (0.94 to 1.24)	0.98 (0.88 to 1.09)	0.94 (0.53 to 1.55)	1.34 (1.20 to 1.50)	1.08 (0.96 to 1.23)	0.79 (0.57 to 1.07)
	≥3	1.18 (0.97 to 1.43)	0.81 (0.69 to 0.94)	0.37 (0.09 to 0.99)	1.36 (1.15 to 1.60)	1.13 (0.94 to 1.37)	0.59 (0.32 to 0.99)
Hospital length of stay (days)	≤10 (Ref)						
	11–20	0.77 (0.70 to 0.84)	1.22 (1.14 to 1.31)	0.99 (0.69 to 1.39)	0.98 (0.91 to 1.06)	2.50 (2.30 to 2.71)	4.61 (3.48 to 6.17)
	21–30	0.68 (0.60 to 0.77)	1.46 (1.33 to 1.60)	1.02 (0.62 to 1.59)	1.05 (0.96 to 1.16)	4.05 (3.59 to 4.59)	6.19 (4.61 to 8.39)
	>30	0.76 (0.66 to 0.87)	1.85 (1.67 to 2.05)	1.44 (0.79 to 2.45)	1.04 (0.93 to 1.16)	6.95 (5.86 to 8.29)	8.56 (6.43 to 11.51)
Primary cause of death	Others (Ref)						
	Malignant neoplasm	0.82 (0.73 to 0.91)	0.90 (0.83 to 0.98)	0.23 (0.09 to 0.51)	0.57 (0.52 to 0.62)	1.10 (1.00 to 1.22)	5.95 (4.78 to 7.46)
	Heart diseases	1.68 (1.52 to 1.85)	1.16 (1.06 to 1.25)	11.78 (8.27 to 17.27)	0.92 (0.85 to 1.00)	0.58 (0.53 to 0.63)	0.16 (0.06 to 0.34)
	Pneumonia	0.88 (0.76 to 1.00)	1.01 (0.91 to 1.11)	0.69 (0.28 to 1.47)	0.70 (0.63 to 0.78)	0.54 (0.48 to 0.60)	0.18 (0.07 to 0.38)
	Cerebrovascular diseases	0.81 (0.69 to 0.94)	1.21 (1.08 to 1.35)		0.19 (0.16 to 0.22)	0.39 (0.34 to 0.43)	0.10 (0.02 to 0.32)
	Diabetes mellitus	0.98 (0.51 to 1.73)	1.12 (0.71 to 1.78)		1.59 (1.01 to 2.52)	0.85 (0.51 to 1.47)	
	Liver disease	0.76 (0.55 to 1.02)	0.70 (0.55 to 0.87)		1.26 (1.01 to 1.58)	3.05 (2.15 to 4.45)	
	Chronic lower respiratory diseases	1.35 (0.93 to 1.92)	1.43 (1.06 to 1.95)		0.35 (0.24 to 0.50)	0.27 (0.19 to 0.36)	0.32 (0.02 to 1.47)
	Chronic renal failure	1.73 (1.36 to 2.18)	0.83 (0.68 to 1.02)		9.92 (7.39 to 13.60)	1.14 (0.89 to 1.48)	0.16 (0.01 to 0.72)

AOR, adjusted OR; CCI, Charlson Comorbidity Index; CPR, cardiopulmonary resuscitation; ECMO, extra-corporeal membrane oxygenation; HD, haemodialysis; KNHI, Korean National Health Insurance (Medicare); MAP, medical aid programme of Korea (Medicaid); MV, mechanical ventilation.

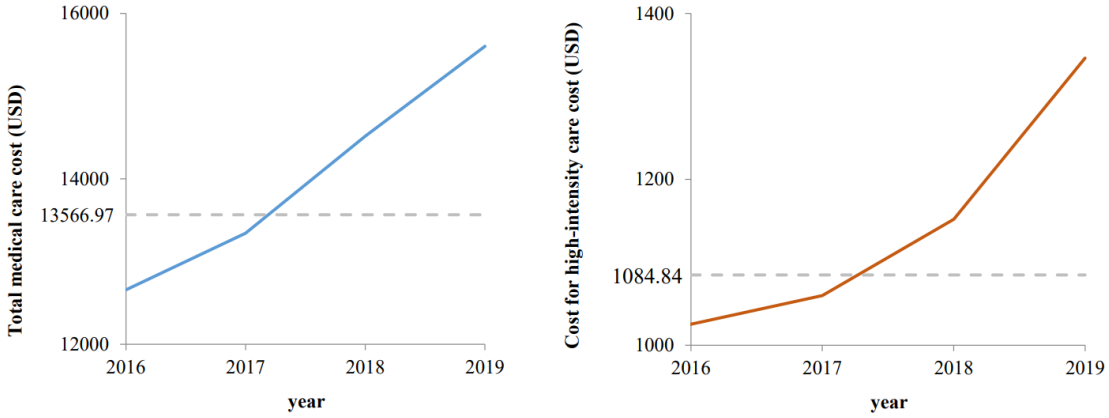

Figure 1 Annual costs of medical care and high-intensity care between 2016 and 2019. 1US$=1200 Korean won (exchange rates as 15 September 2020).

the USA.[44] The cancer mortality rate increased from 122.4 (per 100 000 population) in 2000 to 158.2 in 2019 among Korean adults ≥65 years old.[20] These patients were treated with multiple drugs and different procedures to manage their symptoms and comorbidities. According to the national data,[45] a considerable number of Korean patients with cancer continued to receive intensive EOL care during their last year. In our study, the elderly population who died from liver and heart diseases had significantly higher odds of receiving a transfusion (AOR=3.05) and ECMO (AOR=11.78), respectively.

South Korea's national health insurance system covers approximately 97% of the overall population, and most medical procedures are reimbursed on a fee-for-service basis.[46] However, medical expenditures related to cancer and liver disease overburden patients, and their families, and the national health insurance system. In addition to the factors suggested in this study, researchers reported that institutional factors are related to high-intensity care and costs.[26 47] Higher use of EOL intensive care was likely to be seen in tertiary hospitals located in metropolitan areas.[26 32] South Korea is a country with regional disparities in medical resources, and medical services are highly concentrated in the capital area.[26] The differences according to the types of medical facility were not analysed because this study aimed to grasp the actual situation based on the data of medical institutions where intensive care is performed the most.

The results of this study should be interpreted with caution due to several limitations. First, this study only included older people treated at tertiary hospitals, so it may not be representative of samples in other hospitals in South Korea. Moreover, HIRA data did not include detailed clinical and personal information such as behaviour factors or clinical test results. Therefore, the ability to adjust for severity in patients at the end of life was limited. Additionally, the data used in this study contain only the billing data requested from each hospital. Thus, data for patients that were not covered by healthcare insurance might have been excluded. Findings in this study may differ from the treatments received by the actual patients. Despite the above limitations, this study is significant in that it is the first study to represent the recent status of high-intensity care using the national healthcare data while the LST Decisions Act[14] was enacted in South Korea. The large population-based cohort data over an extended period of time also contribute to identifying relevant patients to examine intensive care use and costs within a specified EOL period.

CONCLUSION

Findings in this study indicate the increasing trend of intensive care such as HD, transfusion and chemotherapy among the older population at the end of life. Such a trend leads to a surge in medical expenses and can burden

Table 4 Annual costs of medical care and high-intensity care between 2016 and 2019

	Total medical care costs (US$)		Costs of high-intensity care (US$)	
Year	M±SD	F (p)	M±SD	F (p)
2016[a]	12 658.01±12 024.34	31.76 (<0.001)	1025.35±1673.01	15.52 (<0.001)
2017[b]	13 342.26±12 413.70	a<b< c,d	1059.88±1718.25	a,b<c,d
2018[c]	14 515.49±13 336.26		1151.81±1813.63	
2019[d]	15 601.92±14 533.23		1346.15±1992.03	

1 US$=1200 Korean won (exchange rates as 15 September 2020). All data were compared by one-way analysis of variance followed by post-hoc Scheffé test.
a,b,c,and d are numerical values representing the mean of tatal medical care costs, respectively.

Table 5 Factors associated with total medical costs and high-intensity care costs

		Total costs of medical (US$)			Costs of high-intensity care (US$)		
Characteristics	**Categories**	**M±SD**	**F or t (p)**	**β (p)**	**M±SD**	**F or t (p)**	**β (p)**
Age at death (years)	65–69 (Ref)	16 143.47±15 582.01	**85.81** (<0.001)		1434.01±2083.23	**103.02** (<0.001)	
	70–74	14 660.27±13 405.48		**−0.09** (<0.001)	1248.05±1978.07		**−0.09** (<0.001)
	75–79	13 596.59±12 210.42		**−0.15** (<0.001)	1088.18±1739.56		**−0.17** (<0.001)
	80–84	12 142.19±10 767.91		**−0.23** (<0.001)	892.27±1400.85		**−0.26** (<0.001)
	≥85	10 413.51±9316.51		**−0.33** (<0.001)	633.43±1037.53		**−0.40** (<0.001)
Sex	Male (Ref)	13 981.42±12 913.57	**6.63** (<0.001)		1086.14±1726.05	1.92 (0.055)	
	Female	13 006.18±12 334.40		0.01 (0.571)	1083.08±1765.87		**0.07** (<0.001)
Health insurance	KNHI (Ref)	13 707.80±12 824.00	**4.49** (<0.001)		1093.37±1753.35	**4.49** (<0.001)	
	MAP	11 812.97±10 565.80		**−0.11** (<0.001)	978.59±1605.87		**−0.05** (0.039)
CCI (score)	0	13 530.26±12 587.60	0.34 (0.794)		1062.38±1746.70	**3.09** (<0.001)	
	1	13 569.30±12 939.86		**−0.03** (0.018)	1092.85±1765.16		−0.01 (0.397)
	2	13 772.15±12 893.67		**−0.05** (0.021)	1158.54±1687.10		0.00 (0.879)
	≥3	13 789.98±12 389.02		−0.03 (0.340)	1300.62±1646.37		0.04 (0.337)
Hospital length of stay (days)	≤10	7326.84±5953.82	**4767.52** (<0.001)		664.24±938.84	**27.66** (<0.001)	
	11–20	15 691.11±9521.86		**0.69** (<0.001)	1248.98±1717.34		**0.34** (<0.001)
	21–30	22 514.48±12 433.31		**1.23** (<0.001)	1665.78±2316.56		**0.57** (<0.001)
	>30	33 201.97±18 513.44		**2.09** (<0.001)	2385.97±3097.66		**0.96** (<0.001)
Primary cause of death	Other (Ref)	13 374.86±12 696.54	**20.14** (<0.001)		1175.73±1831.63	**7.45** (<0.001)	
	Malignant neoplasm	15 923.57±14 236.86		**−0.11** (<0.001)	1352.67±2026.95		**−0.08** (<0.001)
	Heart diseases	13 433.93±13 523.54		**0.22** (<0.001)	1007.62±1653.36		0.00 (0.919)
	Pneumonia	12 837.28±10 602.34		**−0.13** (<0.001)	755.46±1202.47		**−0.27** (<0.001)
	Cerebrovascular diseases	10 751.20±8084.54		**−0.04** (0.043)	442.29±735.83		**−0.36** (<0.001)
	Diabetes mellitus	11 757.65±9993.45		**−0.23** (0.007)	955.13±1113.34		−0.17(0.109)
	Liver disease	12 284.37±13 206.63		**−0.10** (0.016)	1776.84±2502.11		**0.29** (<0.001)
	Chronic lower respiratory diseases	11 854.59±8273.87		**−0.30** (<0.001)	485.23±850.84		**−0.48** (<0.001)
	Chronic renal failure	12 519.63±11 471.11		**−0.16** (<0.001)	1400.02±1573.48		0.08 (0.102)

Statistics in bold in table 5 are significant based on the significance level of $p < 0.05$.
CCI, Charlson Comorbidity Index; KNHI, Korean National Health Insurance; MAP, medical aid programme of Korea; 1 US$, 1200 Korean won (exchange rates as 15 September 2020).

both hospitals and the national medical system. The use of intensive care may continue to increase with societal ageing and the increasing prevalence of chronic diseases. Public and healthcare providers' interest in intensive care at the end of life has increased since the LST Decisions Act came into force. Thus, there is a need for continuous assessment of intensive care use at the end of life, on which guidelines may be prepared for appropriate use of medical resources and to provide optimal care.

Author affiliations
[1]College of Nursing, Pusan National University, Yangsan, Republic of South Korea
[2]College of Nursing, Catholic University of Korea, Seoul, Republic of South Korea
[3]Division of Pulmonology, Allergy and Critical Care Medicine, Department of Internal Medicine, BioMedical Research Institute for Convergence of Biomedical Science and Technology, Pusan National University Yangsan Hospital, Yangsan, Republic of South Korea
[4]Nursing Department, Dongnam Health University, Suwon, Republic of South Korea

Acknowledgements The authors would like to acknowledge and thank the Dr Sangjin Lee for his consulting on the statistical analysis methods for big data.

Contributors YL, MJ and TK contributed to the design of the study. YL and MJ were responsible for acquisition of the data. YL, MJ, TK and KY analysed and interpreted the data. YL and MJ wrote the first draft of the paper, which was revised in collaboration with all authors. All authors approved the final manuscript.

Funding This study was supported by the National Research Foundation of Korea (NRF) grant funded by the Korean government (No. 2018R1C1B5086285).

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 Not required.

Ethics approval This study was approved by the Institutional Review Board of the P university in South Korea (Pusan National University Institutional Review Board/2019_114_HR). Personal identification numbers in the HIRA database were anonymised before providing to researchers.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement No data are available. We cannot share our data because of administrative data of Korean government. Data can be available only after applying to the Healthcare Bigdata Hub (https://opendata.hira.or.kr/op/oph/selectCnfcUseAplPrsnt.do) and getting approval from the Health Insurance Review & Assessment Service in South Korea.

ORCID iD
Minjeong Jo http://orcid.org/0000-0002-1101-4008

REFERENCES

1 Ministry of Health and Welfare, Korea Institute for Health and Social Affairs. OECD health statistics 2018, 2021. Available: http://www.mohw.go.kr/react/jb/sjb030301vw.jsp?PAR_MENU_ID=03&MENU_ID=032903&CONT_SEQ=345950&page=1
2 Ko S, Jeong Y. Social values in end-of-life care. Korea Institute for health and social Affairs, 2014. Available: http://repository.kihasa.re.kr/handle/201002/13882
3 Langton JM, Blanch B, Drew AK, *et al*. Retrospective studies of end-of-life resource utilization and costs in cancer care using health administrative data: a systematic review. *Palliat Med* 2014;28:1167–96.
4 Chiang J-K, Kao Y-H. Predictors of high healthcare costs in elderly patients with liver cancer in end-of-life: a longitudinal population-based study. *BMC Cancer* 2017;17:568.
5 Luta X, Maessen M, Egger M, *et al*. Measuring intensity of end of life care: a systematic review. *PLoS One* 2015;10:e0123764.
6 Ho TH, Barbera L, Saskin R, *et al*. Trends in the aggressiveness of end-of-life cancer care in the universal health care system of Ontario, Canada. *J Clin Oncol* 2011;29:1587–91.
7 Keam B, Oh D-Y, Lee S-H, *et al*. Aggressiveness of cancer-care near the end-of-life in Korea. *Jpn J Clin Oncol* 2008;38:381–6.
8 Choi J-W, Choi J-W, Kim J-H, *et al*. Association between chronic disease and catastrophic health expenditure in Korea. *BMC Health Serv Res* 2015;15:26.
9 Garrido MM, Prigerson HG, Bao Y, *et al*. Chemotherapy use in the months before death and estimated costs of care in the last week of life. *J Pain Symptom Manage* 2016;51:875–81.
10 Milbrandt EB, Kersten A, Rahim MT, *et al*. Growth of intensive care unit resource use and its estimated cost in Medicare. *Crit Care Med* 2008;36:2504–10.
11 Statistics Korea. Population projections for Korea 2015-2065, 2020. Available: http://kostat.go.kr
12 De la Maisonneuve C, Martins JO. The future of health and long-term care spending. *OECD Journal: Economic Studies* 2014;2015:61–96.
13 Shin H-C, Choi M-Y, Tchoe B-H. The cost of end-of-life care in South Korea. *Korean Journal of Health Policy and Administration* 2012;22:29–48.
14 National Law Information Center. Act on decisions on life-sustaining treatment for patients in hospice and palliative care of at the end of life, 2016. Available: http://www.law.go.kr/LSW/eng/engLsSc.do?menuId=2&section=lawNm&query=hospice&x=33&y=23#liBgcolor0
15 Institute of Medicine. *Clinician-patient communication and advance care planning. in: dying in America*. Washington, DC: The National Academics Press, 2015: 117–220.
16 Health Insurance Review & Assessment Service. Health security system, 2019. Available: http://www.hira.or.kr/dummy.do?pgmid=HIRAJ010000006002
17 Kwok CS, Martinez SC, Pancholy S, *et al*. Effect of comorbidity on unplanned readmissions after percutaneous coronary intervention (from the nationwide readmission database). *Sci Rep* 2018;8:11156.
18 Charlson ME, Pompei P, Ales KL, *et al*. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chronic Dis* 1987;40:373–83.
19 Kim KH. Comorbidity adjustment in health insurance claim database. *Health Policy and Management* 2016;26:71–8.
20 Statistics Korea. 2020 statistics for older people, 2020. Available: http://kostat.go.kr/portal/korea/kor_nw/1/1/index.board?bmode=read&aSeq=385322
21 Korea Informative Classification of Diseases. List of Korean standard classificatino of diseases, 2016. Available: http://www.koicd.kr
22 Park J, Jeon K, Chung CR, *et al*. A nationwide analysis of intensive care unit admissions, 2009-2014 - The Korean ICU National Data (KIND) study. *J Crit Care* 2018;44:24–30.
23 Health Insurance Reveiw & Assessment Service. Health Insuranc for health care cost, 2020. Available: http://opendata.hira.or.kr/op/opc/olapDiagBhvInfo.do
24 Korea Pharmaceutical Information Service, 2019. Available: https://biz.kpis.or.kr/kpis_biz/index.jsp
25 The Korean Association of Internal Medicine. Practice guideline for internal medicine Specilaist: cardiology, 2011. Available: https://www.kaim.or.kr/guideline/?sn=2
26 Kim SH, Kang S, Song M-K. Intensity of care at the end of life among older adults in Korea. *J Palliat Care* 2018;33:47–52.
27 Sato Y, Miyashita M, Sato K, *et al*. End-Of-Life care for cancer patients in Japanese acute care hospitals: a nationwide retrospective administrative database survey. *Jpn J Clin Oncol* 2018;48:877–83.
28 Statistics Korea. Causes and outcomes of death in 2019, 2020. Available: http://kostat.go.kr/portal/korea/kor_nw/1/6/2/index.board?bmode=read&bSeq=&aSeq=385219&pageNo=1&rowNum=10&navCount=10&currPg=&searchInfo=&sTarget=title&sTxt=
29 Statistics Korea. Life expectancy (life expectancy at 0 years old) and life expectancy excluding illness period (healthy life) 2020, 2020. Available: https://www.index.go.kr/potal/main/EachDtlPageDetail.do?idx_cd=2758
30 Baek SK, Chang HJ, Byun JM, *et al*. The association between end-of-life care and the time interval between provision of a do-not-resuscitate consent and death in cancer patients in Korea. *Cancer Res Treat* 2017;49:502–8.
31 Kim HA, Park JY, Kim SJ, Shen J, *et al*. Changes in life-sustaining treatment in terminally ill cancer patients after signing a do-not-resuscitate order. *The Korean Journal of Hospice and Palliative Care* 2017;20:93–9.
32 Hua M, Lu Y, Ma X, *et al*. Association between the implementation of hospital-based palliative care and use of intensive care during terminal hospitalizations. *JAMA Netw Open* 2020;3:e1918675.

33 Kim SJ, Shen J, Ko E, *et al*. Life-Sustaining procedures, palliative care, and cost trends in dying COPD patients in U.S. hospitals: 2005~2014. *Korean J Hosp Palliat Care* 2018;21:23–32.
34 Chen Y-H, Ho C-H, Huang C-C, *et al*. Comparison of healthcare utilization and life-sustaining interventions between elderly patients with dementia and those with cancer near the end of life: a nationwide, population-based study in Taiwan. *Geriatr Gerontol Int* 2017;17:2545–51.
35 Hsu YH, Chou MY, Chen H-M, *et al*. The trend of aggressive treatments in end-of-life care for older people with dementia after a policy change in Taiwan. *J Am Med Dir Assoc* 2020;21:858–63.
36 Lee SI, Hong KS, Park J, *et al*. Decision-Making regarding withdrawal of life-sustaining treatment and the role of intensivists in the intensive care unit: a single-center study. *Acute Crit Care* 2020;35:179–88.
37 Kwon JH, Lee HY, Won YW. *The status of lifelong mediical decision and explore the decision-making model*. Seoul: National Evidence-based Healthcare Collaborating Agency, 2019. https://www.neca.re.kr/lay1/program/S1T11C145/report/view.do?seq=285
38 Lim S, Hong SA, Lee HS. Comparison of consensus on life-sustaining treatment of the elderly in care facilities and family member dyad. *Osong Public Health Res Perspect* 2015;6:126–32.
39 Shin DW, Lee JE, Cho B, *et al*. End-Of-Life communication in Korean older adults: with focus on advance care planning and advance directives. *Geriatr Gerontol Int* 2016;16:407–15.
40 Jo M, Yoo Y-S, Knafl G, *et al*. Family-Clinician communication about end-of-life care in Korea. *J Hosp Palliat Nurs* 2017;19:597–601.
41 Reeve R, Srasuebkul P, Langton JM, *et al*. Health care use and costs at the end of life: a comparison of elderly Australian decedents with and without a cancer history. *BMC Palliat Care* 2017;17:1.
42 Goldsbury DE, O'Connell DL, Girgis A, *et al*. Acute hospital-based services used by adults during the last year of life in New South Wales, Australia: a population-based retrospective cohort study. *BMC Health Serv Res* 2015;15:537.
43 Wong SPY, Kreuter W, O'Hare AM, O'Hare AM. Treatment intensity at the end of life in older adults receiving long-term dialysis. *Arch Intern Med* 2012;172:661–3.
44 Tschirhart EC, Du Q, Kelley AS. Factors influencing the use of intensive procedures at the end of life. *J Am Geriatr Soc* 2014;62:2088–94.
45 Park M, Song I. Medical care costs of cancer in the last year of life using National health insurance data in Korea. *PLoS One* 2018;13:e0197891.
46 Kim L, Kim J-A, Kim S. A guide for the utilization of health insurance review and assessment service national patient samples. *Epidemiol Health* 2014;36:e2014008.
47 David CG, Amos RE, Elliott SF. Trends and variation in end-of-life care for Medicare Beneficiaries with severe chronic illness. The Dartmouth Institute for Health Policy & Clinical Practice. Available: https://folio.iupui.edu/handle/10244/1021