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Temporal Change in the Use of Laboratory and Imaging Tests in One Week Before Death, 2006–2015

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ABSTRACT

Background: To analyze the trends in laboratory and imaging test use 1 week before death among decedents who died in Korean hospitals, tests used per decedents from 2006 to 2015 were examined by using the National Health Insurance Service-Elderly Sample Cohort (NHIS-ESC) dataset.

Methods: The study population consisted of decedents aged ≥ 60 years old with a history of admission and death at a hospital, and tests recorded in the payment claims for laboratory and imaging tests according to the Healthcare Common Procedure Coding System codes were examined. Twenty-eight laboratory and 6 imaging tests were selected. For each year, crude rates of test use per decedents in each age and sex stratum were calculated. Regression analysis was used to examine the temporal changes in the test use.

Results: During the follow-up period, 6,638 subjects included in the sample cohort died. The number of total laboratory and imaging tests performed on the deceased increased steadily throughout the study year from 10.3 tests/deceased in 2006 to 16.6 tests/deceased in 2015. The use of tests increased significantly in general hospitals, however, not in nursing hospitals. Laboratory tests showed yearly increase, from 9.46/deceased in 2006 to 15.57/deceased in 2015, an annual increase of 7.39%. On the other hand, the use of imaging increased from 0.86/deceased in 2006 to 1.01/deceased in 2015, which was not statistically significant.

Conclusion: The use of tests, especially laboratory tests, increased steadily over the years even among those elderly patients at imminent death. Reducing acute healthcare at the end of life would be one target not only to support the sustainability of the health care budget but also to improve the quality of dying and death.

Keywords: Terminal Care; Medical Overuse; Laboratory Test; Imaging Test

INTRODUCTION

With the advent of modern medicine, aging and ailments accompanying it have been increasingly regarded as an entity to be delayed, avoided or even conquered by the medical treatment. In the mid-1970s, Ivan Illich launched a powerful attack on the "medicalization" of dying, claiming that modern medicine had "brought the epoch of natural death to an end.[1]"

Disclosure
The authors have no potential conflicts of interest to disclose.

Author Contributions
Conceptualization: Kim HA. Data curation: Cho M. Formal analysis: Cho M. Investigation: Kim HA, Son DS. Methodology: Son DS. Project administration: Son DS. Supervision: Kim HA, Son DS. Validation: Son DS. Writing - original draft: Kim HA. Writing - review & editing: Son DS.

The examples of medicalization include not only advanced life support, but also increasing numbers of medication and laboratory tests used at the end of life (EOL). Numerous studies point out that elderly individuals, aged 65 or above, contribute to around 30–50% of total healthcare spending in Western countries.[2] While this likely results from an increase in comorbidities due to aging, other studies report that excessive use of health service in proximity to death is responsible for high healthcare costs.[3,4] In many countries, evidence exists for the overuse of aggressive care for dying patients and simultaneous underuse of appropriate palliative care.[5]

There are numerous reports about the cost of EOL from different countries. About 25% of all Medicare's annual costs are accounted for by decedents.[6] Among 264,755 Canadian decedents, the total captured annual cost of $4.7 billion represents approximately 10% of all government-funded health care, of which inpatient care contributed 42.9%.[7] Costs were found to rise sharply in the last 120 days prior to death, predominantly for inpatient care. In an Italian study of 411,812 subjects, the deceased were significantly more likely to have at least one hospital admission, emergency department visit, drug prescription, specialist visit and laboratory test than their age-matched surviving counterparts.[3] In Korea, the pattern of health care utilization before death has been reported mostly among cancer patients with average costs increasing each year and hospitalization as a major driver of the total medical cost.[8,9]

It is plausible that the need for care is the greatest at the EOL, but the content of health care service used should be examined to reduce waste and discomfort. One area of concern is polypharmacy. Patients at the EOL commonly experience a gradual increase in the medication burden and previous studies demonstrate that up to 20% of patients receiving palliative care services regularly take more than eight medications.[10-12] Polypharmacy results in waste not only from the cost of medication per se but also from the adverse effects of medication and the cost of treating them. Other area is laboratory and imaging test use. Between 5% and 95% of laboratory tests used in current health care service, are considered inappropriate, or of minor clinical relevance, depending on the criteria used for establishing appropriateness.[13,14] Aside from the direct cost, imprudent use of tests leads to huge indirect costs arising from the secondary evaluation and treatment of minor abnormalities detected by tests. Notwithstanding, age and sex adjusted rate of test use increased by 8.5% annually from 2000–2001 to 2015–2016, a 3.3 fold increase over 16 years in the UK primary care.[15] It is, thus, highly likely that the use of inappropriate tests is another source of the rise in EOL care expenditure. However, the trend of test use at the EOL has not previously been reported.

In this study, we analyzed trends in laboratory and imaging test use in a week before death among decedents who died in Korean hospitals. The temporal change in test use was quantified and specific tests with the greatest increase in use were identified using a sample of nationwide claims data in Korea from 2006 to 2015.

METHODS

Data sources

Data were obtained from the National Health Insurance Service-Elderly Sample Cohort (NHIS-ESC) dataset of Korea. The NHIS-ESC is a stratified random sample of 10% of the population of the 5.5 million people older than 60 years who maintained medical insurance as of December 2002. Database incorporated sex, age, date of death, primary diagnosis,

secondary diagnosis, surgical or medical treatment administered, whether the individual was an inpatient or outpatient, type of insurance (i.e., NHI or Medical Aid), medical expenses, and medical institution identification number. Primary diagnoses at death were coded according to the International Classification of Disease, Tenth Revision (ICD-10). We defined 8 illnesses as follows (with coding variance among physicians for the same syndrome accounted for): diabetes mellitus (E10– E14), myocardial infarction (I21–I25), chronic heart failure (I50), chronic renal failure (N17–N19), cerebrovascular disease (I60–I63), chronic obstructive pulmonary disease (J43, J44, J47), hypertension (I10–I16), and malignant neoplasm (C). Hospital characteristics, including type (general or nursing hospital), bed numbers and location, were determined using the medical institution ID.[16] Information was collected over a period of 14 years (from 2002 to 2015) without personal identification.

Study population

The study population consisted of decedents aged ≥ 60 years old with a history of admission and death at a hospital between January 1, 2003 and December 31, 2015. Because the number of decedents from year 2003 to 2005 were less than 100, data from year 2006 were used.

Included tests

We studied tests recorded in the payment claims for laboratory and imaging tests according to the Healthcare Common Procedure Coding System codes provided by the Health Insurance Review and Assessment service: AJ001–003.[17] Tests were counted based on an individual (number of tests per decedents) during the last week before the study subject died. Separate components of a test (e.g., individual components of a full blood count), were grouped and counted as one test. Specific tests included (28 laboratory, 6 imaging, **Supplementary Table 1**) were selected because they are commonly used tests in current clinical practice and are included in the Quality and Outcomes Framework of the report by O'Sullivan et al.[15]

Statistical analyses

Categorical descriptive data are presented as percentages and continuous descriptive data as means ± SDs. For each year we counted the total number of tests recorded among decedents, and calculated crude rates of test use per decedents in each age (60–74, 75–84, ≥ 85) and sex stratum. Rates were calculated for the total number of tests, each of the 34 specific tests, and the laboratory or imaging tests. Regression analysis was used to examine the temporal changes in the test use.

We also calculated the trend in test frequency per deceased throughout the study year. In addition to the change in the number of tests ordered per patient, the proportion of decedents who underwent multiple tests was examined. To do this, we calculated the percentage of study subjects who received 0 test, 1–10 tests or > 10 tests in a week before death over the study years. We examined the differences between these proportions across years using the χ^2 test. We used Stata (version 14.2) for data extraction and cleaning, and R (version 4.2.1) for statistical analyses.

Ethics statement

This study used data from a publicly available database and ethical approval was waived by Kangdong Sacred Heart Hospital institutional review board (2019-06-001) in accordance with institutional policy for such studies. No informed consent was required from patients due to the nature of public data from NHIS.

Table 1. Baseline characteristics of included decedents

Variables	2006 (n = 105)	2007 (n = 148)	2008 (n = 320)	2009 (n = 407)	2010 (n = 440)	2011 (n = 879)	2012 (n = 974)	2013 (n = 1,131)	2014 (n = 1,041)	2015 (n = 1,193)
Age, mean ± SD	78.51 ± 7.25	78.45 ± 7.18	79.28 ± 7.49	79.72 ± 7.33	79.45 ± 7.18	79.96 ± 6.91	80.96 ± 6.88	81.40 ± 6.26	82.27 ± 6.49	82.58 ± 6.32
Sex, male, %	51	33	48	51	53	52	51	50	51	51
Primary diagnosis at death, %										
Diabetes	3.81	3.38	1.88	1.97	1.59	1.48	1.85	1.86	2.21	1.84
Myocardial infarction	3.81	2.70	2.81	2.70	1.14	1.25	1.64	1.77	2.11	2.10
Chronic heart failure	2.86	2.03	0.31	1.97	1.36	2.05	1.75	2.12	2.02	1.93
Cerebrovascular disease	4.76	7.43	8.75	7.37	6.14	10.13	8.32	7.25	6.24	5.78
Chronic obstructive pulmonary disease	1.90	0.68	2.19	1.23	0.45	0.80	1.85	1.24	2.11	1.76
Malignant neoplasms	31.43	25.68	25.94	31.45	29.55	27.42	22.90	22.81	19.40	21.63
Chronic renal failure	1.90	4.05	2.81	3.93	2.73	3.07	3.49	3.01	2.98	3.60
Hypertension	1.90	3.38	2.19	3.19	1.59	2.39	3.59	3.01	2.69	3.44
Level of income, %										
Medical aid beneficiary	20.00	20.95	11.56	17.44	17.73	16.50	14.27	13.79	13.93	11.99
≤ 20%	15.24	18.92	11.25	15.97	12.95	13.42	16.32	14.85	15.27	14.17
> 20%, ≤ 40%	5.71	11.49	9.06	9.58	8.64	9.33	8.01	9.02	8.45	9.22
> 40%, ≤ 60%	13.33	9.46	11.88	13.27	11.82	9.90	11.70	12.11	11.53	12.91
> 60%, ≤ 80%	14.29	14.86	15.31	12.04	14.32	15.93	14.37	16.53	16.43	17.10
> 80%	31.43	24.32	40.94	31.70	35.00	34.93	35.32	33.69	34.39	34.62
Number of hospital beds, %										
< 250	52.38	50.68	49.69	48.89	43.41	30.03	35.32	36.69	35.73	38.98
250–499	23.81	22.97	21.25	22.60	19.55	26.51	40.25	38.46	40.25	39.73
≥ 500	23.81	27.03	29.06	29.48	38.41	45.85	27.00	27.76	26.71	25.06
Location, %										
Metropolitan cities	40.00	33.78	40.94	41.52	44.09	43.12	35.52	35.63	38.23	37.55
Other area	60.00	66.22	59.06	58.48	55.91	56.88	64.48	64.37	61.77	62.45

RESULTS

During the follow-up period, 6,638 subjects included in the sample cohort died. The demographic features of the deceased are shown in **Table 1**. Age at death increased each study year and about half of the deceased were male. Malignant neoplasm was the leading primary diagnosis at death followed by cerebrovascular disease.

The number of total laboratory and imaging tests performed in a week before death on the deceased increased steadily throughout the study year from 10.3 tests/deceased in 2006 to 16.6 tests/deceased in 2015 (**Table 2**). The increase was observed in all age brackets (from 10.2 to 18.4 in 60–74 years old, from 11.1 to 17.6 in 75–84 years old and from 8.42 to 14.5 in ≥ 85 years old).

The trend of increase in tests before dying differed according to the hospital type. Those who died in nursing hospitals had less tests, and the test rate tended to decrease over the study years, albeit not significantly (**Fig. 1**). On the other hand, the use of tests increased significantly in general hospitals among all age groups except for those ≥ 85 years. The increase in tests before dying was observed both in males and females (**Supplementary Table 2**).

Table 2. Number of tests performed per decedents by age

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	*P* for trend
60–74	10.19	14.05	12.00	13.47	17.35	12.69	19.25	16.90	20.52	18.40	0.003
75–84	11.06	9.84	7.82	9.27	11.66	10.92	14.25	16.26	17.54	17.65	< 0.001
≥ 85	8.42	7.45	7.62	9.02	9.77	7.75	13.86	15.68	13.64	14.50	0.002
Total	10.31	10.50	9.09	10.40	12.87	10.54	15.15	16.18	16.56	16.58	< 0.001

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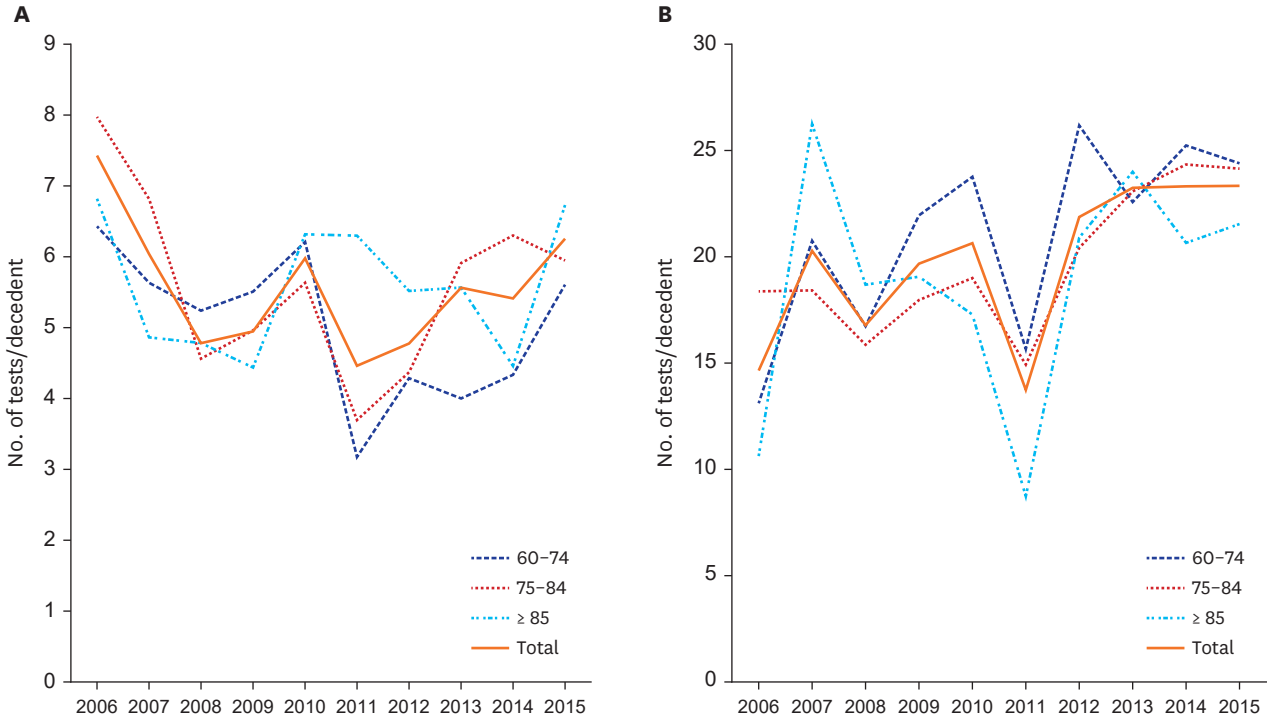

Fig. 1. The number of tests performed on decedents in a week before death from year 2006–2015. (**A**) Nursing hospital, (**B**) General hospital.

When laboratory and imaging tests were separately analyzed, laboratory tests were used substantially more than imaging across the entire study period (**Table 3**). In addition, laboratory tests showed yearly increase, from 9.46/deceased in 2006 to 15.57/deceased in 2015, an annual increase of 7.39%. Over the same period, the use of imaging increased from 0.86/deceased in 2006 to 1.01/deceased in 2015, and the increase was not statistically significant. Because some of the more sophisticated tests are not available in nursing hospitals and thus may have resulted in lower use of lab tests, we selected core tests that are frequently used in both types of hospitals (complete blood count, liver function test, renal function test, electrolyte, and chest X-ray) and analyzed the trend of their use according to hospital type. As shown in the **Supplementary Table 3**, core test use did not increase in the nursing hospital, either.

Dying process of cancer patients may be different from that of non-cancer patients, such that cancer patients resort to more comfort care at the EOL with withholding of advanced care. However, we found out that the use of tests increased over the study period in cancer patients as well as in non-cancer patients (**Supplementary Table 4**). Contrary to our expectation, older group of cancer patients (≥ 75 years) had significant increase of test use before death, which was not the case among younger group.

Table 3. Number of tests performed per decedents by test type

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	*P* value
laboratory	9.46	9.52	8.27	9.31	11.43	9.26	14.14	15.15	15.52	15.57	< 0.001
imaging	0.86	0.98	0.83	1.09	1.43	1.28	1.02	1.03	1.04	1.01	0.488
Total	10.31	10.50	9.09	10.40	12.87	10.54	15.15	16.18	16.56	16.58	< 0.001

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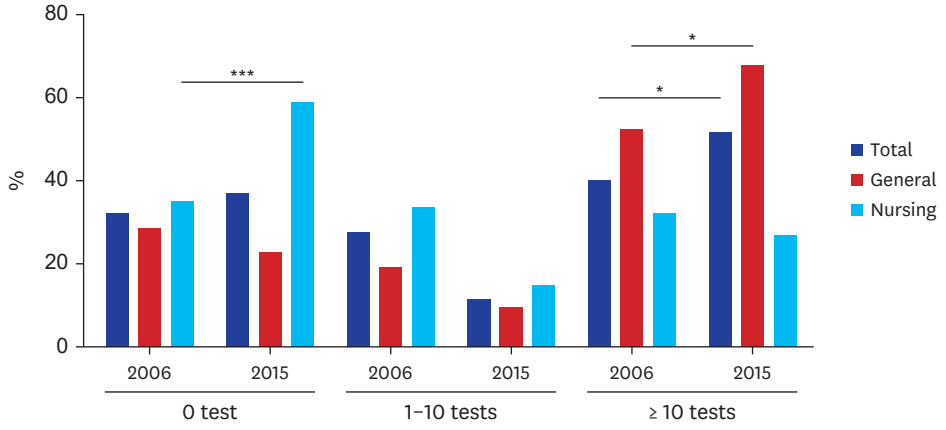

Fig. 2. The proportion of decedents who had 0, 1–10, and > 10 tests in a week before death in year 2006 and 2015.
* denoted $P < 0.05$, *** denotes $P < 0.001$.

Patients who did not have any tests in a week before death increased from 32.38% to 36.88%, while those who had more than 10 tests also increased from 40.00% to 51.63% (**Fig. 2**). This was again different between general and nursing hospitals. The proportion of patients who had 0 test decreased from 28.57% to 22.73% while those who had more than 10 tests increased from 52.38% to 67.77% in the former. In the nursing hospitals, the proportion of patients who had 0 test increased from 34.92% to 58.86%, while those who had more than 10 tests decreased from 31.75% to 26.48%.

The most commonly ordered tests were full blood counts, electrolyte battery and liver function tests (**Supplementary Table 5**). These tests also showed the highest increase throughout the study period. Simple X-ray and anti-nuclear antibody decreased over the study years.

DISCUSSION

With the rise in medical expenditure over the last decades around the world, reducing low value care and waste has been an important issue to alleviate the strain on the governmental health care budget. In this study, the temporal changes in the laboratory and imaging test use in a week before death among decedents who were admitted to Korean hospitals were analyzed from 2006 to 2015. The results show that the number of total laboratory and imaging tests performed on the deceased increased steadily throughout the study year in all age groups with the increase mostly driven by laboratory tests. The increase in tests occurred in general hospitals and not in nursing hospitals.

Diagnostic laboratory test repertoire has expanded enormously over the past decades, and it is reported that more than 70% of clinical decisions are influenced by test results.[18] The problem of inappropriate laboratory test use has also been raised over the years, with tests reportedly being used for "non-medical reasons," such as reassuring patients with unexplained complaints. In a US study of 11,637,763 Medicare beneficiaries, the most common low-value services were found to be laboratory testing.[19] However, laboratory test use increases year after year, as well as the percentage of test requests flagged as urgent, challenging the health care resources on a daily basis.[13]

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We focused on the issue of test use at the EOL, because death within 1 week is the worst hard outcome the meaning of which cannot be changed over the years. The fact that those who died at general hospitals had higher number of tests may stem from the fact that they were deemed to have more reversible cause of clinical deterioration. However, the increase in test use did not change the outcome of death within 1 week throughout the study period in those decedents. Some of the tests, such as rheumatoid factor or vitamin D level does not seem appropriate in its face value for those patients dying within a week.

The use of tests increased over the study period in cancer patients as well as in non-cancer patients, especially among older group (≥ 75 years). In a study of adults > 65 years with aggressive non-Hodgkin lymphoma, patients diagnosed in 2013 or later experienced higher rates of hospitalizations in the last 30 days of life compared with those diagnosed before 2013, underscoring the increasing intensity of care at the EOL in this population.[20] Because health care utilization of patients at the EOL depends on the socio-cultural background and health care system, the factors driving aggressive EOL care need to be defined and alleviated to help improve EOL care.[21]

Increased use of testing at the EOL in Korea might result from various factors. First, it may reflect the overestimation from patients or their family about the value of laboratory tests. For example, a systematic review of 54 outcomes across 32 studies assessing benefit expectations of medical screening and tests showed that the majority of participants overestimated benefit, while underestimating harm.[22] Secondly, clinicians were also found to have inaccurate expectations of benefits or harms, such that they more often underestimated rather than overestimated harms and overestimated rather than underestimated benefits.[23] In Korea, compensation issue is also at play because compared to OECD member countries, Korean health care reimbursement system undercompensate for physician time while relatively overcompensate laboratory and imaging tests.[24] Laboratory tests are often used to set off inadequately short physician consultation time which has significantly undermined physician-patient relationship.[25] Lastly, fear of litigation for undertesting is a real issue, especially at the EOL which may lead to increases in test usage.[26]

Our study has limitations. Firstly, although the NHI-ECS database is representative of the Korean elderly population, it only extracts data from a proportion of subjects from the whole population, so generalizability issue may still be present. An updated study using whole population data is needed to shed light on the prudent use of EOL health care resources. Second, the selection of 34 tests is arbitrary albeit based on references. Due to the bureaucratic issue of using NHI database, our study could not be performed in a timely manner, and the last follow-up year was 2015, which is outdated. However, with the advent of newer laboratory tests year by year and with the issue of overcompensation of tests compared to physician cognitive service not corrected, we believe this finding did not ameliorate in recent years. The selection of observation point at 1 week before death is also arbitrary and longer observation, such as 1 month or 6 month before death would have provided more comprehensive picture. However, coding inaccuracy was inevitable such as the date of test requested, because the NHI data are based on payment claims which are not filed on a daily basis. As a result, as the duration of hospitalization increases, it would be more difficult to verify how close the tests were performed in proximity to death. In addition, because deeming any patients as EOL is becoming more and more difficult in modern medicine, short observation time before death would be more relevant in pointing out the futile use of tests at EOL. Lastly, the fact that a patient died in a week cannot be used to automatically label that

patient as EOL patient, and some decedents included, albeit elderly, may have had reversible cause of death.

In conclusion, we showed that the use of tests (especially, laboratory) increased steadily over the years even among those elderly patients at imminent death. Reducing acute healthcare at the EOL would be one target not only to support the sustainability of the health care budget but also to improve the quality of dying and death.

SUPPLEMENTARY MATERIALS

Supplementary Table 1
Included laboratory and imaging tests

Click here to view

Supplementary Table 2
Number of tests performed per decedents by sex

Click here to view

Supplementary Table 3
Use of core tests according to hospital type

Click here to view

Supplementary Table 4
Use of tests among cancer decedents by age group

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Supplementary Table 5
Annual number of tests performed per decedents by test items

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