RESEARCH ARTICLE

Cost-effectiveness Outcomes of the National Gastric Cancer Screening Program in South Korea

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Abstract

Background: Although screening is necessary where gastric cancer is particularly common in Asia, the performance outcomes of mass screening programs have remained unclear. This study was conducted to evaluate cost-effectiveness outcomes of the national cancer screening program (NCSP) for gastric cancer in South Korea. Materials and Methods: People aged 40 years or over during 2002-2003 (baseline) were the target population. Screening recipients and patients diagnosed with gastric cancers were identified using the NCSP and Korea Central Cancer Registry databases. Clinical outcomes were measured in terms of mortality and life-years saved (LYS) of gastric cancer patients during 7 years based on merged data from the Korean National Health Insurance Corporation and National Statistical Office. We considered direct, indirect, and productivity-loss costs associated with screening attendance. Incremental cost-effectiveness ratio (ICER) estimates were produced according to screening method, sex, and age group compared to non-screening. Results: The age-adjusted ICER for survival was 260,201,000-371,011,000 Korean Won (KW; 1USD=1,088 KW) for the upper-gastrointestinal (UGI) tract over non-screening. Endoscopy ICERs were lower (119,099,000-178,700,000 KW/survival) than UGI. To increase 1 life-year, additional costs of approximately 14,466,000-15,014,000 KW and 8,817,000-9,755,000 KW were required for UGI and endoscopy, respectively. Endoscopy was the most cost-effective strategy for males and females. With regard to sensitivity analyses varying based on the upper age limit, endoscopy NCSP was dominant for both males and females. For males, an upper limit of age 75 or 80 years could be considered. ICER estimates for LYS indicate that the gastric cancer screening program in Korea is cost-effective. Conclusion: Endoscopy should be recommended as a first-line method in Korea because it is beneficial among the Korean population.

Keywords: Cost-effectiveness analysis - economic evaluation - gastric cancer screening - stomach neoplasm - Korea

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Introduction

Gastric cancer is particularly common in East Asian countries such as Japan, Korea, and China (Leung et al., 2008). The high mortality from gastric cancer is due primarily to late presentation. Recently, the diagnosis of early gastric cancer has increased and endoscopic treatments, such as endoscopic mucosal resection and endoscopic submucosal dissection, have increased the long-term outcomes and quality of life of patients with early gastric cancer (Park et al., 2011). Because of this more favorable prognosis of early gastric cancer, systematic mass screening of gastric cancer has been provided in Japan and Korea (Choi et al., 2011). Attributed to the mass-screening program in Japan, early gastric cancer represented 50% and 68% of all gastric cancer in 1950-1990 and in 2004, respectively (Nishi et al., 1995; Committee of National Statistics, 2007). In Korea, approximately 46-67% of gastric cancers screen-detected with endoscopy were early-stage cancers (Choi et al., 2011). Additionally, 5-year survival was improved if the cancers were detected by screening rather than at an open access clinic (Whiting et al., 2002).

Although screening is necessary, mass screening methods have shown diverse or unclear outcomes in previous studies (Leung et al., 2008). Endoscopic screening of a high-risk group, Chinese men between 60 and 70 years old, was shown to be cost-effective in 2003 (Dan et al., 2006). In Japan, an indirect X-ray method was more cost-effective than direct radiography and endoscopy in a 1995 report (Babazono and Hillman, 1995).Photofluorography screening methods have also shown a decrease in gastric cancer mortality among the group screened (Miyamoto et al., 2007). Combined screening of serum pepsinogen testing and barium digital radiography was more effective for a high-risk population

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in Japan (Ohata et al., 2005). In Iran, performance of national-level endoscopy screening was effective for a high-risk region.(Mansour-Ghanaei et al., 2012) The cost-effectiveness of mass screenings may also vary according to the cost of the screening examination. For example, endoscopic screening costs in Korea are less than 50% of those in other countries, like Japan and Singapore (Chang et al., 2012).

Currently, in Korea, direct upper-gastrointestinal X-ray (a "UGI series") or endoscopy has been recommended biennially for people 40 years and older since the implementation of the National Cancer Screening Program (NCSP) in 1999 (Kim et al., 2011). The NCSP was expanded to go beyond Medicaid recipients from 2002, and since then, the performance outcomes of endoscopy and a UGI series as vehicles of a mass screening program for gastric cancer have remained unclear. A cost-effectiveness outcome is affected by costs, clinical outcomes, and participation rates in screening. Thus, identifying cost-effective approaches to promote population-based screening is important, but there are only a few reports about the subject (Andersen et al., 2004).

In this study, we investigated the impact of the current NCSP for gastric cancer by taking both costs and survival outcomes into account. The 7-year survival and life years saved were assessed to determine the improved outcomes of gastric cancers detected through the mass screening program. Costs related to gastric cancer screening were considered in examining the incremental cost for the additional outcome of a UGI series and endoscopy versus not screening.

Materials and Methods

Study population and data sources

The study population was Koreans aged 40 years and older in 2002-2003 (baseline). The target population and participation in NCSP in the baseline years were identified through the NCSP database. People who underwent the NCSP with a UGI series or endoscopy in 2002 or 2003 (baseline) were assigned to UGI or Endoscopy groups, respectively. People who had not been diagnosed with gastric cancer at baseline and did not participate in the NCSP for gastric cancer in not only 2002 or 2003 but also the following 7 years were assigned to the non-screened group. The gastric cancer diagnosis in these three groups at baseline and during the 7-year follow-up was examined by linking to the Korean Central Cancer Registry database.

Mortality information during the 7-year follow-up period was obtained by merging two national databases from the Korean National Health Insurance Corporation and the National Statistical Office. Cost data related to the gastric cancer screening directly or indirectly were collected from the internal accounts of screening units in hospitals, published studies, and national statistics. Finally, a comparison of survival outcomes following 7-year outcomes, until 2009 or 2010, was made across age groups.

Cost-effectiveness analyses

To determine the cost-effectiveness of UGI and endoscopy, the cost and effectiveness outcomes of each group were compared with the non-screened group. Cost

Table 1. Cost Data for the Analyses

Costs	Amount	Source
UGI series screening including consultation fee	KW 46,190	National Cancer Screening Program guidebook 2002-2011.
Endoscopic screening including consultation fee	KW 44,950	Division of Cancer Policy, Ministry of Health and Welfare.
Further testing due to false-positive results from the NCSP for UGI group: (a) Endoscopy + (b) biopsy+ (c) consultation fee (supposing 50% of visits were made with a designated oncologist)	KW 92,564 (44,950+27,910+19,704)	(a) (b): National Cancer Screening Program guidebook 2002-2011. Division of Cancer Policy, Ministry of Health and Welfare
Further testing due to false-positive results from the NCSP for UGI group: (b) biopsy + (c) consultation fee (supposing 50% of visits were made with a designated oncologist)	KW 47,614 (27,910+19,704)	(c): Obtained from the Division of Medical Information and Technology, Yonsei University Health System, Seoul
Transportation for a visit (round-trip)	KW 11,172	The Third Korea National Health and Nutrition Examination Survey (KNHANES III), 2005
Productivity loss costs for half day due to screening test or further examination		Statistics Korea, 2009-2011. Ministry of Employment and Labor, Employment Policy Office
Equation: (average daily wage × economic activity rate + daily wage for housework × non-economic activity rate) × ½		Park et al. A Study on the Estimation of Cost Related to Cancer Care and Burden of Cancer Diseases 2003. National Cancer Center
(1) For males		
Age 40-49	KW 67,408	
Age 50-59	KW 56,897	
Age over 60	KW 23,513	
(2) For females		
Age 40-49	KW 35,341	
Age 50-59	KW 30,827	
Age over 60	KW 25,478	

*All costs were for 2009 or were adjusted to 2009 values

data used in the cost-effectiveness model are presented in Table 1.

Three combinations were considered in the cost-effectiveness models of this study. For COST I, only costs directly related to screening were considered, such as screening costs and further examination costs after false-positive results from the NCSP (Ministry of Health and Welfare, 2002-2011). Transportation costs, needed for screening attendance or follow-up examination costs, were considered as indirect screening costs and COST II consisted of direct and indirect screening costs (The Third Korea National Health and Nutrition Examination Survey (KNHANES III), 2005). COST III included all costs in COST II plus productivity loss, defined as loss of salary due to absence from work to participate in the NCSP for gastric cancer. The average daily wage was calculated by dividing the annual average salary of each age group by the number of working days within 1 year (Statistics Korea 2009-2011). For women, even if they did not have economic activity, the daily wage of housework was considered for calculating their productivity loss costs, supposing that women's labor as housewives would have continued (Park et al., 2003). The productivity loss cost due to screening attendance was assumed as approximately half of the average daily wage, weighted for economic and non-economic activity rates (Table 1). COST I, COST II, and COST III were applied only to the screened groups of NCSP. All costs were inflated to values for the year 2009 using the National Consumer Indexes (Statistics Korea, 2012). For the base-case cost-effectiveness analysis, COST III was used.

As effectiveness measures of NCSP, 7-year survival and life-years saved (LYS) within 7 years from the baseline years for people with gastric cancers were examined. People who had no mortality record during the follow-up period were assumed to live until the last year of their life expectancy.

Both effectiveness outcomes and costs were presented per 100,000 people in each age group for comparison. The outcome information for the entire population was age-adjusted for the standard population in Korea. (Korean Statistical Information Service (KOSIS), 2012) To determine cost-effectiveness of NCSP for gastric cancers, costs and effectiveness outcomes in the UGI and Endoscopy group were compared with the non-screened group according to gender.

Several scenarios were examined as sensitivity analyses. First, a scenario with various upper age limits for gastric cancer screening in NCSP, which were 60, 65, 70, 75, and 80, was simulated. Second, it was supposed that the cost of an endoscopy examination increased two-fold. Third, the average productivity loss cost was assumed to increase by 10%. Fourth, although conscious sedation, along with endoscopy screening, was not incorporated in the base case analysis, it was supposed that 50% of endoscopy screenings involved conscious sedation, and thus, screening costs for the endoscopy group were increased.

Data management and analyses were performed using Microsoft Excel™ and SAS 9.2 software. Figures representing incremental costs and effectiveness for strategies were made using decision analysis software (TreeAge Pro 9.0., TreeAge Software Inc., Williamstown, MA).

Results

Study population

At baseline, the target population for gastric cancer screening was 8,361,420 men and 8,683,567 women. Among these, 4.06% and 2.68% of males underwent UGI series and endoscopy screening, respectively (Table 2). For women, 6.68% underwent a UGI series and 4.64% chose endoscopic screening. For both male and female participants in NCSP, UGI series were used approximately 1.5-fold more than endoscopy.

The proportion of female participants was higher than males. Among the target population, approximately 71.8% of males and 69.3% of females had never undergone gastric cancer screening in NCSP in the 7 years since the baseline (Table 2). Males who were younger than 55 years or older than 75 years at baseline were less likely to participate in the NCPS (the proportion in the non-screening group was over 70%). Males whose age was between 60 and 74 in the baseline years participated in the NCSP more than other age groups and yet approximately 60% of them had not participated in gastric cancer screening over the 7 years. Women in their 50s and 60s participated most in the NCSP for gastric cancer versus other age groups. Similar to men, the non-participation rate in NCSP was over 88% for females aged 75 years and older (Table 2).

Survival and life-years saved outcomes of NCSP versus non-screening

The survival outcome from gastric cancer was highest for the Endoscopy group for both males and females. The non-screening group had the lowest survival outcome, worse than the UGI and endoscopy groups. Per 100,000 men, the age-adjusted gastric cancer mortality rate in the UGI, endoscopy, and non-screening groups was 384, 365, and 429 (Figure 1). The gastric cancer mortality was lower for females than males and on average, 152, 100, and 176 females died in the UGI, endoscopy, and non-screening groups, respectively.

Table 2. Screening Participation Rates in 2002-2003

Age group	Males			Females		
	UGI series	Endoscopy	Non-screening	UGI series	Endoscopy	Non-screening
40-44	3.37%	2.21%	77.61%	0.58%	4.04%	70.08%
45-49	3.30%	2.49%	78.61%	6.75%	4.66%	66.84%
50-54	4.56%	2.96%	73.38%	8.07%	5.72%	62.61%
55-59	5.26%	3.20%	65.74%	8.87%	6.16%	61.88%
60-64	6.19%	3.56%	59.79%	8.60%	6.13%	63.01%
65-69	6.40%	3.24%	60.80%	7.59%	5.13%	68.94%
70-74	5.05%	2.26%	58.17%	5.55%	3.38%	77.17%
75-79	4.93%	1.69%	83.20%	3.23%	1.87%	88.84%
≥80	2.70%	0.69%	93.08%	1.18%	0.78%	98.33%
Total	4.06%	2.68%	71.81%	6.68%	4.64%	69.31%

*People in the non-screening group did not participate in the National Cancer Screening Program for 7 years from the baseline of 2002-2003. Total participation rates were age-adjusted

The survival outcomes were greater for younger age groups (Figure1). For men aged over 75, negative 7-year survival outcomes were shown for both UGI and endoscopy screening, compared with people who had never taken part in NCSP cancer screening 7 years after baseline. The same result was found for women undergoing UGI screening in 2002-2003. The age-adjusted number of gastric cancer survivors was increased for both UGI and endoscopy groups versus the non-screening group. The age-adjusted incremental life saved for males was 44.72 in the UGI group and 64.19 in the endoscopy group versus the non-screening group per 100,000 people (Table 3). For female participants, the incremental survival outcome of UGI was lower (24.58) than in males, but the survival outcome in endoscopy screening was larger (76.25) than in males. Thus, the relative effect of endoscopy screening compared with a UGI series on gastric cancer survival outcome was larger in women than men.

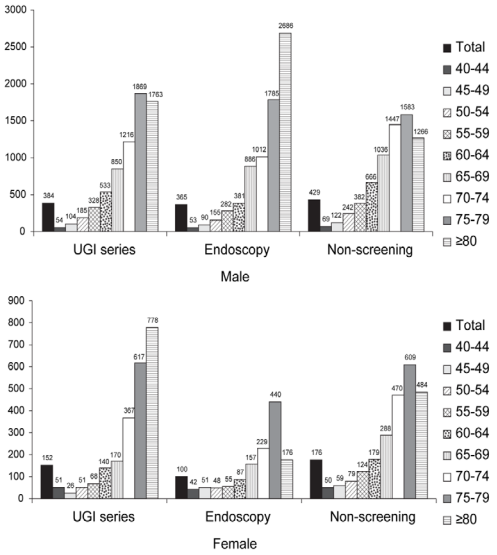

Figure 1. Seven-year Mortality in Gastric Cancer for UGI Series, Endoscopy, and Non-screened Groups between Males andFemales (per 100,000 people). Total frequency values were age-adjusted

Regarding life-years saved, the endoscopy screening group of men showed the greatest incremental outcome (1,367 years) per 100,000 people after age adjustment (Table 3). Endoscopy (1,035 years) screening was a better strategy than UGI (670 years) for females, considering the LYS on an age-adjusted average. Like the survival outcome, the outcome of life-years gained was inferior for males over 75 years in the UGI and endoscopy groups and for females over 75 years in the UGI group compared with the non-screening group.

Cost-effectiveness analysis of NCSP versus non-screening

The incremental cost-effectiveness ratios of a UGI or endoscopy strategy over non-screening are presented in Table 3. The age-adjusted incremental cost per one survivor of gastric cancer in the UGI screening group was

Table 3. Incremental Cost-effectiveness Ratios of NCSP of Gastric Cancer Versus the Non-screening Group (per 100,000 people)

	Costs	Age group	UGI series vs. Non-screening group				Endoscopy vs. Non-screening group			
			No. gastric cancer deaths averted	ICER (1000 KW/survival)	Life years saved	ICER (1000l KW/survival)	No. gastric cancer deaths averted	ICER (1000 KW/survival)	Life years saved	ICER (1000 KW/survival)
No. gastric cancer deaths averted			ICER (1000 KW/ survival)		Life years saved		ICER (1000 KW/ LYS)			
Male	COST I	Total	44.72	112,775	844	5,973	64.19	74,556	1,367	3,500
	COST II	Total	44.72	138,874	844	7,356	64.19	92,964	1,367	4,364
	COST III	Total	44.72	260,201	844	13,782	64.19	178,700	1,367	8,389
		40-44	14.79	887,205	455	28,838	15.98	819,455	471	27,808
		45-49	17.49	757,872	394	33,671	31.30	420,421	774	16,989
		50-54	57.64	211,248	1,220	9,979	87.03	137,821	1,866	6,429
		55-59	54.48	224,122	873	13,982	99.98	119,818	1,759	6,809
		60-64	133.17	65,410	1,841	4,731	285.75	29,352	3,872	2,166
		65-69	185.62	46,942	1,825	4,775	149.45	56,422	1,502	5,616
		70-74	230.70	37,629	1,578	5,502	435.37	19,275	3,468	2,420
		75-79	-285.63	--	-994	--	-202.00	--	-644	--
		≥80	-497.19	--	-1,164	--	-1420.50	--	-3,806	--
Female	COST I	Total	24.58	196,610	670	7,214	76.25	62,636	1,035	4,613
	COST II	Total	24.58	243,172	670	8,922	76.25	77,697	1,035	5,722
	COST III	Total	24.58	371,011	670	13,614	76.25	119,099	1,035	8,772
		40-44	-0.59	--	-25	--	7.96	1,204,856	295	32,538
		45-49	33.20	288,162	1,051	9,102	8.60	1,117,171	272	35,331
		50-54	27.57	330,791	768	11,880	30.83	295,637	838	10,878
		55-59	56.59	161,656	1,335	6,853	69.12	131,959	1,612	5,657
		60-64	39.61	217,329	745	11,551	92.61	92,138	1,744	4,892
		65-69	118.59	72,644	1,681	5,124	131.03	64,948	1,764	4,825
		70-74	103.29	83,524	1,063	8,114	241.19	35,170	2,481	3,418
		75-79	-8.28	--	-353	--	168.94	50,002	1,015	8,319
		≥80	-294.72	--	-1,494	--	308.12	27,318	1,408	5,980

*Total values for effects and ICERs were age-adjusted. The survival and life years gained outcomes were observed for 5 years from the screening in 2002-2003. -- denotes that NCSP is dominated by the non-screening strategy. All cost estimates were adjusted to 2009 values (exchange rate November 2012: 1 USD = 1,088 KW). Abbreviation: ICER, incremental cost effectiveness ratio; LYS, life years saved

260,201,000 Korean Won, KW; 1USD=1,088KW) for males. In considering COST I and COST II, the ICER was 112,775,000 and 138,874,000 KW/survival for men with UGI screening. Endoscopy screening for males showed lower (decreased by 31%) ICER estimates (178,700,000 KW/survival) than a UGI strategy. For females, the endoscopy screening resulted in greater cost-effectiveness (ICER=119,099,000 KW/survival) than UGI screening (371,011,000 KW/survival). The UGI strategy showed smaller incremental costs for saving one life in men than women. On the other hand, the ICER of endoscopy screening was lower for females than males in saving one life from gastric cancer.

The age-adjusted ICER estimates regarding life-years saved with UGI and endoscopy were similar between males and females. To save 1 life-year, both UGI and endoscopy screening were required, at an additional cost of approximately 13,600,000 KW and 8,300,000 KW, respectively. Males of age 60 74 had the greatest benefit in terms of lowest ICER estimates, between 2,166,000 KW/LYS and 5,502,000 KW/LYS from screening for gastric cancer because the outcomes were not additive in screening (Table 3). However, if their age was beyond 75 years, the NCSP dominated. For females, the UGI screening was most cost-effective (5,124,000 KW/LYS) for the age group 65-69. Endoscopy screening was more cost-effective than UGI for females, with the ICER estimates only below 8,000,000 KW/LYS for the age group in their 50s and over (Table 4).

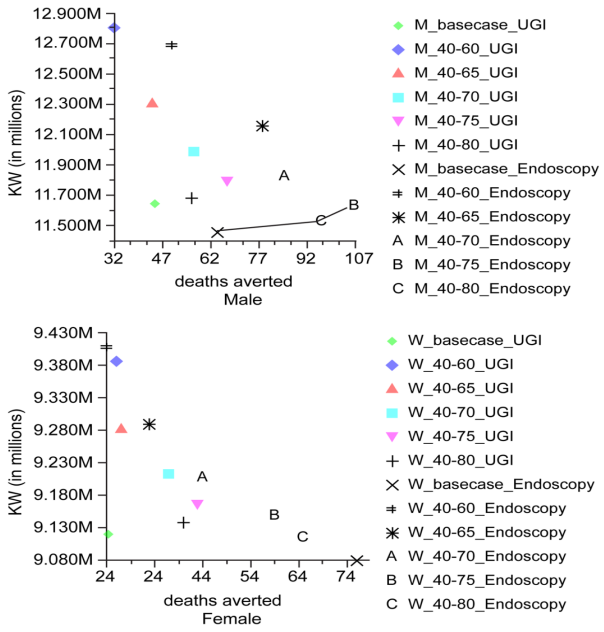

Figure 2. Incremental Survival Outcomes and Costs Over Non-screening Group for Gastric Cancer Screening Strategies with Different Upper Age Limits

Sensitivity analyses

The output of sensitivity analyses according to age categories by 10 years are summarized in Table 4. In the base case analyses, an endoscopy strategy had lower costs than UGI. When assuming the endoscopy screening-related costs were increased by doubling the costs or by considering conscious sedation use, the gap in ICER estimates between endoscopy and UGI was reduced versus the base case. However, endoscopy was still a more cost-effective strategy with lower ICER than a UGI strategy for males and females.

Figure 2 presents the results of the incremental costs and the number of deaths averted by UGI and endoscopy screenings versus non-screening by supposing different upper age limits, from 60 to 80, for males and females. For males, the current endoscopy screening with no upper age limit and two other endoscopy screenings with upper age limits of 75 and 80 were dominant strategies. For females, the current NCSP with endoscopy was the dominant strategy, with no competition.

Discussion

In this study, we investigated the cost-effectiveness of gastric cancer screening for 7 years in Korea. The survival and life-years gained with a UGI series and endoscopy were improved compared to non-screening and incremental costs per effectiveness unit seemed to be acceptable. The clinical outcome may be a natural consequence, because gastric cancer detected through systematic mass screening

Table 4. Sensitivity Analyses with Incremental Cost-effectiveness Ratios Regarding Life Years Saved during 7 years (ICER: 1,000 KW/LYS; 1 USD=1,088 KW)

Age		UGI vs. non-screening				Endoscopy vs. non-screening			
		Base case	Endoscopy cost increase by twice	Productivity loss cost increase by 10%	Sedation use for endoscopy by 50%	Base case	Endoscopy cost increase by twice	Productivity loss cost increase by 10%	Sedation use for endoscopy by 50%
Male:	Total	13,782	13,871	14,466	13,867	8,389	11,677	8,817	10,402
	40s	31,009	31,172	32,766	31,164	21,233	28,502	22,464	25,684
	50s	11,425	11,499	12,019	11,495	6,591	9,062	6,943	8,104
	60s	4,571	4,795	4,894	4,793	3,016	4,628	3,110	4,003
	70s	12,555	12,666	12,934	12,661	4,104	6,296	4,232	5,446
	>80	--	--	--	--	--	--	--	--
Female:	Total	13,614	13,737	15,014	13,808	8,772	12,929	9,755	11,312
	40s	19,135	19,274	21,062	19,270	33,843	49,021	37,633	42,875
	50s	8,947	9,027	9,965	9,025	7,705	11,341	8,568	9,868
	60s	7,196	7,271	7,897	7,269	4,860	7,313	5,368	6,320
	70s	17,511	17,717	19,214	17,712	4,476	6,750	4,935	5,829
	>80	--	--	--	--	5,980	9,037	6,578	7,799

*-- denotes that NCSP is dominated by the non-screening strategy

would include a greater proportion of early stage cancers (Choi et al., 2011). However, to our knowledge, this is the first report identifying the cost-effectiveness of the current mass screening of gastric cancers based on actual data of a population-based study population in Korea.

Overall, endoscopy screening was more cost-effective than the UGI method because its incremental cost per LYS was only 60-64% of the cost of UGI. This finding is consistent with previous research showing improved efficacy and usefulness of endoscopy compared to UGI X-ray screening (Kim et al., 2000; Tsubono and Hisamichi, 2000). Because the cost of endoscopy examination of Korea is considerably lower than the UGI examination cost, the incremental costs of endoscopy screening were competitive in Korea (Chang et al., 2012). A previous report found that until the cost of endoscopy screening was 3-fold more than a UGI series, the endoscopy method should be the dominant strategy over UGI in Korea (Lee et al., 2010). That is, the superior cost-effectiveness outcome of endoscopy is dependent on future screening-related costs and the practitioner performing the endoscopy screening.

Among the NCSP participants in 2002 and 2003, more people chose UGI screening rather than endoscopy. Although endoscopy was a preferred method for gastric cancer screening by the majority of population in Korea from survey in 2008 and 2010, people who had undergone UGI screening were likely to prefer UGI while people with an endoscopy screening within the previous 2 years preferred endoscopy for the following screening method (Choi et al., 2009; Hahm et al., 2011; Park et al., 2011). Dissatisfaction in endoscopy screening participants was related to insufficient explanation from the staff and the physical environment (Lee et al., 2011). A UGI series method may have clinical utility as an alternative for people who have discomfort or difficulty in endoscopy screening. Nevertheless, considering the dominant cost-effectiveness of endoscopy, it should be recommended as the first-line method in Korea.

With regard to various upper age limits, this research found that the current endoscopy screening with no age limit was the dominant strategy for males and females. Additionally, upper age limits of 75 and 80 years are also recommended for screening the male population. Indeed, the incidence and mortality risk of gastric cancer increased in older people (Ito et al., 2009; Nam et al., 2009). Meanwhile, considering the greater proportion of non-screening among males over 70 years old in 2002 and 2003 (Table 2), a more intensive screening strategy with endoscopy may be needed for the aged, especially those with a higher risk of gastric cancers (Chung et al., 2012).

Although the baseline of this study was the initial stage at which NCSP expanded its coverage, the participation rate in gastric cancer screening was low: 6.74% for males and 11.32% for females. The number of participants has increased since then, but it still seems that gastric cancer screening is underused in Korea (Choi et al., 2009). Thus, to promote participation in gastric cancer screening, it is recommended that NCSP provides appropriate education and intervention, highlighting the superior cost-effectiveness outcomes of endoscopy while encouraging use of both endoscopy and UGI methods rather than removing UGI series from the recommendations of NCSP (Choi et al., 2009).

Our study has several methodological advantages over previous studies. First, the study subjects were not a cohort group but the entire population of Korea, subjects who underwent NCSP gastric cancer screening in baseline. Although there have been a couple of reports investigating the cost-utility outcomes of gastric cancer screening, those Markov models were constructed based on a hypothetical cohort group (Gupta et al., 2011; Chang et al., 2012). Using large and absolute data from the whole population, this research could produce unconditional performance outputs of NCSP with no selection bias.

Second, to examine the effect of the initial NCSP screening of gastric cancer over non-screening, we defined the subjects in the non-screening group to have no record of NCSP participation during the observation period of 7 years since baseline. Although some people with no NCSP participation might have undergone an opportunistic screening, in our research, we could measure the actual cost-effectiveness outcomes of NCSP for gastric cancer screening over non-screening pertaining to organized programs.

Our study has some limitations that can be addressed in future research. First, because it deviated from the objective of our study, the cost-effectiveness outcomes by different screening cycles were not investigated. Indeed, previous research using a simulated Markov-model suggested that annual, rather than biennial, endoscopic screening was the most cost-effective for the male population in Korea (Chang et al., 2012). The screening interval should depend on the growth rate of the cancer. Although gastric cancer is preceded by a relatively prolonged latency period, (Correa, 2004) the screening outcome could be also affected by the failure to detect cancer at the time of screening and the capabilities of physicians or endoscopists in screening services (Cha et al., 2012). A recent report found that although the number of gastric cancers detected and interval cancers were a little greater in the initial screening round compared with the subsequent round, the proportion of early cancer stage among detected cancers was greater in the subsequent round (Choi et al., 2011). People who receive a negative result from NCSP may not pay full attention to symptoms or the following screening, and thus the outcome of interval cancers may be worse for the screened group. In future research, the cost-effectiveness outcomes of gastric cancer screenings according to different frequencies and intervals of NCPS attendance should be determined.

Second, although the gastric cancer incidence is not affected by a mass screening program, socioeconomic status or behavioral characteristics of NCSP participants may differ from those of people in the non-screening group. For example, people who are concerned with cancer screening may pay more attention to healthy lifestyle than the unconcerned. Although no out-of-pocket cost is required for participants to undergo NCSP screening, people with higher income levels were more likely to be rescreened than medical aid recipients (Hahm et al., 2011; Lee et al., 2011). Then, the better outcomes of NCSP may

be associated with different risks of the people screened. However, considering the significantly greater proportion of early stage gastric cancer detected in screening, healthy behaviors would not seem to explain the improved outcomes from mass screening (Miyamoto et al., 2007).

Third, in this research the ICER estimates were determined using survival and LYS while quality adjusted life years are often used in evaluating ICER values as an integrated effectiveness measure. However, given the greater proportion of early stage cancers from screening detection, considering the quality of the lengthened survived time period would be associated with greater difference in effectiveness outcome and thus, the ICER estimates would be more favorable with mass screenings. Thus, measuring quality of life in gastric cancer patients according to different cancer stages should be pursued to identify the intrinsic quality of population-based screening programs.

Fourth, although several cost types related to screening participation were considered in this study, treatment costs for gastric cancers were not considered, nor were indirect screening costs. Treatment costs may not differ between screening and clinic detection. As mentioned above, early stage cancers represented an increased share of all gastric cancers, and thus, the ICERs including treatment costs would be more favorable for a screening strategy over non screening. By incorporating treatment costs and other costs, such as indirect and productivity loss costs, associated with treatments, the cost-effectiveness outcomes from subpopulations of society could be evaluated.

In our study, we tracked the subjects for 7 years, which was the longest follow-up period possible with the available data. However, a longer follow-up period, like 10 or 20 years, may be necessary to determine the ultimate outcomes of NCSP in Korea. Additionally, the NCSP participation rate and the use of screening methods have changed. Furthermore, the epidemiological characteristics of gastric cancer, like the incidence, would vary as well as cost-related factors. Thus, research on the cost-effectiveness of NCSP needs to be conducted continuously to examine trends in cost-effectiveness outcomes of an organized gastric cancer screening scheme. In so doing, a better cost-effective recommendation could be made within the context of an organized screening program.

In the present study, we evaluated the cost-effectiveness outcomes of mass screening for gastric cancer using population-based data. Among the strategies, endoscopy screening was superior to a UGI series for males and females in terms of cost-effectiveness outcomes compared to non-screening. These findings may be useful in developing a more cost-effective organized cancer screening program with improved quality of screening, which may result in increased participation and improved outcomes of the NCSP in Korea.

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