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Screening for Gastric Cancer: The Usefulness of Endoscopy

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Gastric cancer screening is common in countries with high prevalence rates of gastric cancer. However, data supporting the effectiveness of gastric cancer screening are lacking. Thus, the aim of this review was to examine the current evidence on gastric cancer screening. Herein, we reviewed radiographic and endoscopic tests as methods of gastric cancer screening. Previous cohort studies and case-control studies have demonstrated reduced gastric cancer mortality in study populations that had undergone gastric cancer screening with radiographic tests. Recently, a case-control study in Japan reported a 30% reduction in gastric cancer mortality when screening was undertaken via endoscopy. Also, endoscopic screening for gastric cancer exhibited higher sensitivity and specificity than radiographic screening. Moreover, most cost-effectiveness analyses on the best strategy for detecting early gastric cancer have generally concluded that endoscopy is more cost-effective than radiographic testing. Although data on the impact of endoscopy screening programs on gastric cancer mortality are limited, recent study results suggest that gastric cancer screening by endoscopy in average-risk populations performs better than radiography screening. Further evaluation of the impact of these screening methods should take into account cost and any associated reduction in gastric cancer mortality.

Key Words: Stomach neoplasms; Screening; Endoscopy; Upper gastrointestinal series

INTRODUCTION

Until recently, gastric cancer comprised the second most common type of cancer worldwide. In 2012, gastric cancer fell to fifth place, behind lung, breast, colorectum, and prostate cancers.¹ Nevertheless, gastric cancer remains the third most common cause of cancer death.¹ Asian countries, including China, Japan, and Korea, in particular, report some of the highest incidences of gastric cancer in the world.² While its incidence has declined in Korea in recent decades, gastric cancer was still the second most common cancer in the country in 2010 (crude incidence rate: 60.3 per 100,000; age-standardized incidence rate: 41.8 per 100,000).³

In countries with high prevalence rates of gastric cancer, like China, Japan, and Korea, gastric cancer screening is common. Since 1960, as a result of mass gastric cancer screening

implementation using photofluorography (via indirect upper gastrointestinal series [UGIS]), which facilitates early detection, Japan has achieved improvements in survival and cure rates.⁴⁻⁶ In recent years, endoscopy has been increasingly utilized in opportunistic screening for gastric cancer.⁷ In Korea, the nationwide gastric cancer screening program has provided endoscopy and UGIS as initial screening methods.⁸ However, apart from the countries where gastric cancer is highly prevalent, many countries generally lack national guidelines or recommendations for gastric cancer screening. Additionally, data in support of the effectiveness of gastric cancer screening are lacking.

Thus, the aim of this review was to examine current evidence on gastric cancer screening and to determine the most cost-effective screening strategies. Herein, we reviewed radiographic and endoscopic tests as screening methods for gastric cancer, as these two methods are most commonly provided by population-based organized screening programs.

CURRENT POPULATION-BASED GASTRIC CANCER SCREENING PROGRAMS

The incidence and mortality of gastric cancer differ signifi-

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cantly by region, population, and race distribution. Additionally, healthcare systems, health resources, and social and economic conditions may greatly affect gastric cancer prevention and screening strategies. At present, the East Asia region, particularly Japan, Korea, and other countries with high incidence rates of gastric cancer, have achieved tangible results from their screening programs, as well as from preventive interventions. However, no nationwide screening of gastric cancer has been reported in the United States, Europe, or other areas with low incidence rates of gastric cancer.

Japan

Around 1960, gastric cancer screening via photofluorography began to be offered in the Miyagi prefecture and has since been adopted nationwide.⁹ In 1983, under the Health Service Law for the Aged, annual gastric cancer screening via photofluorography was introduced for all residents aged 40 years and older. The screening rate for gastric cancer was 11.8% in 2007, following a trend of declining participation in screening programs since the early 1990s.¹⁰ In 2008, a Japanese research group for cancer screening recommended guidelines for gastric cancer screening.⁹ To do so, they evaluated four gastric cancer screening methods: photofluorography, endoscopy, serum pepsinogen testing, and *Helicobacter pylori* antibody testing. On the basis of a benefit/harm balance, the research group recommended gastric cancer screening using photofluorography for both population-based and opportunistic screening.⁹ The other methods were not recommended for population-based screening because of insufficient evidence.⁹ Notwithstanding, endoscopy has recently replaced photofluorography as the initial mass screening method in several Japanese cities.¹¹

Korea

In Korea, the Korean Gastric Cancer Association and National Cancer Center established national guidelines for gastric cancer screening in 2001. These guidelines recommend biennial gastric cancer screening for men and women aged 40 years or older via either UGIS or endoscopy.¹² Based on these guidelines, a nationwide gastric cancer screening program was started in 2002 as part of the National Cancer Screening Program (NCSP). The NCSP now provides support for biennial gastric cancer screening via either UGIS or endoscopy for Medical Aid Program recipients and National Health Insurance beneficiaries aged 40 or older.¹³ The participation rate for gastric cancer screening provided by the NCSP increased from 12.7% in 2002 to 43.9% in 2012.^{14,15} In addition to the NCSP, opportunistic gastric cancer screening is also widely available in Korea. According to the Korean National Cancer Screening Survey, the participation rate for opportunistic and organized gastric cancer screening has increased significantly,

from 39.2% in 2004 to 70.9% in 2012.¹⁶

Other countries in Asia

In China, although gastric cancer is the second most common cancer, no nationwide screening program has been established. Therefore, early detection of gastric cancer relies on opportunistic screening alone, although endoscopy is widely available in major cities. Notwithstanding, UGIS and serum pepsinogen testing are not commonly practiced in China for reasons of cost and availability.⁷

Singapore also lacks a nationwide gastric cancer screening program for the population.⁷ As the risk of developing gastric cancer in Singapore is deemed intermediate, screening is more effectively targeted at high-risk groups than at the population level. A cost-benefit analysis of gastric cancer screening conducted in Singapore showed that screening by endoscopy was most cost-effective in moderate- to high-risk populations.¹⁷

In Taiwan, gastric cancer screening is limited to the high-risk population. Two prevention campaigns have been implemented in Matzu Island where the prevalence and incidence of gastric cancer were exceptionally high.^{18,19} From 1995 to 2004, subjects with low serum concentrations on the serum pepsinogen test (<30 ng/mL) received endoscopy.¹⁸ From 2004 to 2005, those with *H. pylori* infection underwent endoscopy and *H. pylori* eradication,¹⁹ and this population-based program showed that *H. pylori* eradication significantly reduced the incidence of atrophic gastritis and gastric cancer.²⁰

EVIDENCE ON GASTRIC CANCER SCREENING

The efficacy of cancer screening is best assessed with randomized controlled trials to determine mortality reductions in screened versus unscreened subjects. Although randomized controlled trials represent the most reliable method for evaluating the impact of screening on cancer risk, such intervention studies are not feasible in most countries because gastric screening is already widely conducted. Furthermore, obtaining accurate estimates of mortality reductions requires long-term follow-up of large populations.

Radiographic tests (photofluorography, UGIS, or barium-meal studies)

No randomized controlled trial addressing the use of radiographic tests in gastric cancer screening has been published. Meanwhile, four case-control studies and four cohort studies have been conducted to evaluate the effect of gastric cancer screening by photofluorography on mortality (Table 1); one case-control study was conducted in Venezuela,²¹ while the others were conducted in Japan.^{4,22,23} Most of the case-

Table 1. Observational Studies of Gastric Cancer Screening by Upper Gastrointestinal Series

Author	Study population	Age (follow-up), yr	No. of subjects	Results
Case-control study				Odds ratio (95% CI)
Oshima et al. (1986) ²²	Osaka, Japan	40+	Case/control Male: 54/156 Female: 37/105	Male: 0.595 (0.338–1.045) Female: 0.382 (0.185–0.785)
Pisani et al. (1994) ²¹	Tachira, Venezuela	35+	Case/control All: 241/2,410	All: 1.26 (0.81–1.91) ^{a)} Male: 1.52 (0.94–2.47) ^{a)} Female: 0.77 (0.33–1.78) ^{a)}
		35+	Case/control All: 85/375	All: 0.47 (0.24–0.98) ^{b)} All: 0.25 (0.12–0.51) ^{c)}
Fukao et al. (1995) ⁴	Miyagi, Japan	50+	Case/control Male: 126/364 Female: 72/213	Male: 0.32 (0.19–0.53) Female: 0.63 (0.34–1.16)
Abe et al. (1995) ²³	Chiba, Japan	30–89	Case/control Male: 527/1,552 Female: 293/861	Male: 0.371 (0.242–0.568) Female: 0.458 (0.263–0.797)
Tsubono et al. (1999) ²⁴	Meta-analysis (Osaka, Miyagi, Chiba)	3 Japanese case-control studies	Case/control Male: 706/2,072 Female: 402/1,179	Male: 0.39 (0.29–0.52) Female: 0.50 (0.34–0.71)
Cohort study				Relative risk (95% CI)
Inaba et al. (1999) ²⁵	Gifu, Japan	35+ (40 mo)	Screened/unscreened Male: 4,934/6,536 Female: 4,208/8,456	Gastric cancer Male: 0.67 (0.29–1.53) Female: 1.41 (0.42–4.74)
				All cause Male: 0.83 (0.70–0.98) Female: 0.82 (0.64–1.04)
Mizoue et al. (2003) ⁵	Japan Collaborative Cohort Study	40–79 (8 yr)	Screened/unscreened Male: 12,999/23,156 Female: 17,772/33,385	Gastric cancer Male: 0.54 (0.41–0.70) Female: 0.74 (0.51–1.07)
				All cancer Male: 0.80 (0.70–0.90) Female: 0.70 (0.59–0.83)
Lee et al. (2006) ²⁶	Japan Public Health Center-based prospective study	40–59 (13.1 yr)	Screened/unscreened: 15,189/26,961	All cause Male: 0.71 (0.64–0.77) Female: 0.74 (0.66–0.83)
				Gastric cancer 0.60 (0.43–0.83) All cancer 0.78 (0.68–0.89) All cause 0.69 (0.64–0.76)
Miyamoto et al. (2007) ²⁷	Miyagi, Japan	11 yr	Screened/unscreened Male: 8,177/11,916 Female: 9,203/12,098	Gastric cancer Male: 0.52 (0.36–0.75) ^{d)} Female: 0.51 (0.27–0.96) ^{d)}
				All cancer Male: 0.79 (0.72–0.87) ^{d)} Female: 0.73 (0.64–0.83) ^{d)}

CI, confidence interval.

^{a)}Excluded cases within 6 months before the date of diagnosis; ^{b)}Excluded cases within 1 month before the date of diagnosis among subjects who underwent at least one screening test; ^{c)}Excluded cases within 6 months before the date of diagnosis among subjects who underwent at least one screening test; ^{d)}Adjusted for age or age and sex.

control studies conducted in Japan demonstrated a 40% to 60% reduction in gastric cancer mortality with photofluorography screening.^{4,23,24} Nonetheless, the study conducted in Venezuela reported no detectable reduction in gastric cancer mortality. Fukao et al.,⁴ Oshima et al.,²² and Abe et al.²³ reported that the summary odds ratios of three case-control studies for ever-screened versus never-screened subjects were 0.39 (95% confidence interval [CI], 0.29 to 0.52) for men and 0.50 (95% CI, 0.34 to 0.72) for women in reducing gastric cancer mortality.²⁴ They discerned that the Japanese screening program with photofluorography is effective in reducing gastric cancer mortality.

Regarding the four cohort studies, one study lacked statistical power and did not show a significant difference in the relative risk (RR) of mortality.²⁵ The cohort study conducted by Mizoue et al.⁵ revealed significantly reduced mortality in men (RR, 0.54; 95% CI, 0.41 to 0.70), while the reduction in mortality was not significant in women (RR, 0.74; 95% CI, 0.51 to 1.07). Another cohort study with a 13-year follow-up in Japan reported a 40% reduction in gastric cancer mortality in screened versus unscreened subjects (RR, 0.60; 95% CI, 0.43 to 0.83).²⁶ The most recent study, conducted by Miyamoto et al.,²⁷ also reported a significant mortality reduction in both men and women who had undergone screening versus those who had not (RR, 0.52; 95% CI, 0.36 to 0.75 in men; RR, 0.51; 95% CI, 0.27 to 0.96 in women).

Endoscopy

Only a few studies have evaluated the effectiveness of endo-

scopic screening in terms of mortality reduction (Table 2). One community-based case-control study was conducted to evaluate the reduction in gastric cancer mortality by endoscopic screening.²⁸ In this study, compared to patients who had never undergone screening for gastric cancer, the odds ratios were 0.695 (95% CI, 0.489 to 0.986) for patients who underwent endoscopic screening and 0.865 (95% CI, 0.631 to 1.185) for those who underwent radiographic screening.

Regarding cohort studies, one study was conducted in an area with a high incidence of gastric cancer in Linqu County, China.²⁹ From 1989 to 1999, endoscopic screening was conducted for 4,394 residents. Both the incidence and mortality rates of gastric cancer were monitored until 2000. Over this period, 85 cases of gastric cancers were detected, 29 of which were early cancers. However, compared with the overall mortality for Linqu County, the standard mortality ratio was 1.01 (95% CI, 0.72 to 1.37). Another cohort study conducted in Japan by Hosokawa et al.³⁰ reported that the RR for gastric cancer death in the examined group was 0.347 (95% CI, 0.140 to 0.860) when compared with the nonexamined group. The RRs in men and women were 0.217 (95% CI, 0.068 to 0.699) and 0.684 (95% CI, 0.160 to 2.929), respectively. In conclusion, they recommended the application of endoscopy in population-based screening programs for gastric cancer in regions or countries where gastric cancer mortality is high.

TEST ACCURACY

Usually, the accuracy of a screening test is indicated by its

Table 2. Observational Studies of Gastric Cancer Screening by Endoscopic Screening

Author	Study population	Age (follow-up), yr	No. of subjects	Results
Case-control study				Odds ratio (95% CI)
Hamashima et al. (2013) ⁴⁰	Tottori, Japan	40+	Case/control Male: 288/1,604 Female: 122/688	All: 0.695 (0.489–0.986) Male: 0.560 (0.359–0.873) Female: 1.075 (0.601–1.922)
Cohort study				Relative risk (95% CI)
Riecken et al. (2002) ²⁸	Linqu, China	35–64 (11.5 yr)	4,394	SMR gastric cancer All: 1.01 (0.72–1.37) Male: 1.13 (0.77–1.57) Female: 0.65 (0.26–1.32)
				SMR all cause All: 0.71 (0.63–0.81) Male: 0.80 (0.69–0.92) Female: 0.56 (0.44–0.70)
Hosokawa et al. (2008) ²⁹	Fukui, Japan	40–75	Screened/unscreened 2,192/9,571	Gastric cancer All: 0.347 (0.140–0.860) Male: 0.217 (0.068–0.699) Female: 0.684 (0.160–2.929)

CI, confidence interval; SMR, standardized mortality ratio.

sensitivity and specificity. A good screening test must have high sensitivity and high specificity. The most common method used to calculate sensitivity and specificity involves the follow-up of persons who have undergone screening to ascertain the number of cancer cases occurring among them via record linkage to a population-based cancer registry. Table 3 summarizes the reported sensitivities and specificities of radiographic and endoscopic tests as screening methods.

The sensitivity of photofluorography reported from the Japanese studies ranged from 56.8% to 88.5%, whereas specificity ranged from 81.3% to 92.0%.³¹⁻³⁶ Two studies related to the use of endoscopy as a diagnostic test have reported on the accuracy of endoscopy.^{37,38} In the first study, the sensitivity of endoscopy was found to be 77.8%, based on a 3-year follow-up using the cancer registry system of the Fukui prefecture.³⁷ The other study based on a follow-up survey of individual participants recorded an 84.0% sensitivity for endoscopy.³⁸

Two recent studies have compared the accuracies of radiographic tests and endoscopy.^{39,40} One study conducted in Korea utilized data obtained from a population-based national cancer screening database. In that study, the sensitivities of UGIS and endoscopy screening to detect gastric cancer were 36.7% and 69.0%, with specificities of 96.1% and 96.0%, respectively. The other study conducted in Japan reported sensitivities of prevalence screening calculated by the incidence method of 89% for endoscopic screening and 83% for radiographic screening; however, the difference was not significant. The specificities of endoscopy and radiographic screening

were 85% and 86%, respectively. The differences in the sensitivities and specificities between Korea and Japan might be affected by the differences in their respective screening intervals: every 2 years in Korea and every year in Japan. Also, the quality of cancer registry data in the Japanese study was not good, as some of the interval cancers were lost because of insufficient follow-up, and the sensitivity might have been overestimated. Nevertheless, both studies showed that the sensitivity of endoscopic screening for gastric cancer was higher than that of radiographic screening and suggested there should be greater use of endoscopy in gastric cancer screening.

COST-EFFECTIVENESS AND PREFERENCE

In the United States, where gastric cancer incidence rates are low, one study comparing endoscopy versus no screening concluded that one-time screening for the general population at the age of 50 would cost US \$115,664 per quality-adjusted life year (QALY).⁴¹ Another study in the United States concluded that endoscopy screening of less advanced lesions was not cost-effective, except possibly for immigrants from high-risk Asian countries.⁴²

In many Asian countries experiencing high gastric cancer burden, cost-effectiveness analyses of gastric cancer screening are ongoing. In Singapore, where the risk of gastric cancer is low to intermediate, annual endoscopy was deemed the optimal strategy, with an incremental cost-effectiveness ratio (ICER) of US \$44,098 per QALY compared to no screening,

Table 3. Test Accuracies of Upper Gastrointestinal Series and Endoscopy for Gastric Cancer Screening

Author	Follow-up strategy	Follow-up period, yr	Sensitivity, %	Specificity, %	Positive predictive value, %
Radiography test					
Murakami et al. (1990) ³⁶	Cancer registry	1	88.5	92.0	1.40
Sugahara et al. (1991) ³¹	Cancer registry	1	70.4	90.1	1.60
Fukao et al. (1992) ³²	Cancer registry	1	69.3	88.8	2.00
Ishida et al. (1994) ³³	Cancer registry	1	84.1	81.3	0.78
		2	70.1	81.3	0.90
Hosokawa (1995) ³⁴	Cancer registry	1	71.8	81.3	1.1
Abe et al. (2000) ³⁵	Cancer registry	1	56.8	90.7	2.00
Endoscopy test					
Hosokawa et al. (2004) ³⁷	Cancer registry	3	77.8	-	-
Otsuji et al. (1989) ³⁸	Cancer registry		84.0	-	-
Radiography test vs. Endoscopy test					
Choi et al. (2012) ³⁹	Cancer registry	1	UGIS: 36.7 Endo: 69.0	UGIS: 96.1 Endo: 96.0	UGIS: 1.70 Endo: 6.20
Hamashima et al. (2013) ²⁸	Cancer registry	1	UGIS: 83.1 Endo: 88.6	UGIS: 85.6 Endo: 85.1	-

UGIS, upper gastrointestinal series; Endo, endoscopy.

while biennial endoscopy was estimated as the most cost-effective strategy with an ICER of US \$25,949 per QALY.⁴³ The ICERs per QALY in the Singaporean study were lower than those in the United States because of differences in gastric cancer prevalence, healthcare resources, screening strategy costs, and other healthcare-related factors. A study conducted in Taiwan reported that annual screening using endoscopy for high-risk populations whose pepsinogen-I levels were <30 ng/mL at the age of 50 years versus no screening resulted in an ICER of US \$29,741 per life year gained.⁴⁴ In a Japanese study, endoscopy was deemed the best method for detecting early gastric cancer and the cheapest strategy with regard to the cost of identifying one case of gastric cancer.¹¹

The Korean government provides gastric cancer screening as a part of the NCSP and requires many studies to report on the cost-effectiveness thereof. Lee et al.⁴⁵ reported that endoscopy was more cost-effective than UGIS until the cost per cancer case detected becomes 3.7-fold more expensive than UGIS. Another study by Chang et al.⁴⁶ using a time-dependent Markov model to compare 13 different screening alternatives reported annual endoscopy from ages 50 to 80 years was the most cost-effective strategy in men, and biennial endoscopy from ages 50 to 80 years was the most cost-effective in women. Cho et al.⁴⁷ reported that endoscopy ICERs (119,099,000 to 178,700,000 Korean won/survival) were lower than upper gastrointestinal X-ray ICERs (260,201,000 to 371,011,000 Korean won/survival). In Korea, three studies comparing endoscopy versus no screening agreed on endoscopy as the more cost-effective strategy.

In financial terms, the test is not as cost-effective if the cost is too high. The cost of endoscopy is reportedly 3- to 4-fold more expensive than that of radiography testing (photofluorography) in Japan.^{11,48} However, in Korea, the cost of endoscopy is about the same as that of radiographic testing (UGIS) (unit costs for endoscopy and UGIS were US \$34.89 and US \$32.67, respectively, in 2008).⁴⁵

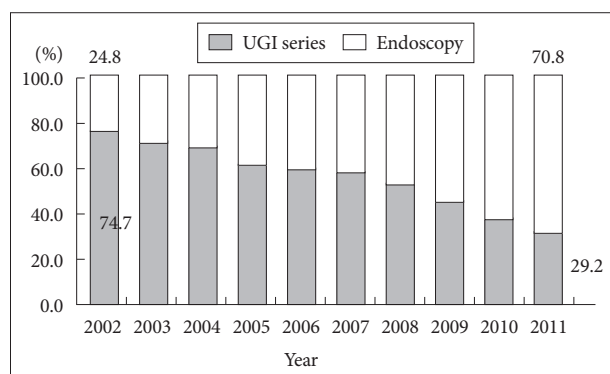


Fig. 1. Trends in the use of upper gastrointestinal (UGI) series and endoscopy among participants in the National Cancer Screening Program in Korea from 2002 to 2011.

For a successful screening program, a high level of participation is required, which likely depends on individual attitudes and preferences about the screening method used. In Korea, endoscopy is the preferred method for gastric cancer screening. According to a Korean National Cancer Screening Survey in 2006, 67% of individuals chose endoscopy as their preferred gastric cancer screening method, while 33% chose UGIS as their preferred method.⁴⁹ Furthermore, the proportion of people choosing endoscopy screening provided by the NCSP has continued to increase annually, from 24.8% in 2002 to 70.8% in 2011 (Fig. 1).⁵⁰

CONCLUSIONS

Endoscopy is widely conducted in clinical settings as a part of routine health check-ups. Some authors have reported higher detection rates of early-stage gastric cancer with endoscopy compared to radiographic tests and have thus concluded that endoscopy is a more sensitive screening method.^{11,39,40,51} Despite the diagnostic advantages of endoscopy, data on the impact of endoscopy screening programs on gastric cancer mortality are limited.

Notwithstanding, the results of recent studies suggest that application of endoscopy in gastric cancer screening programs is more cost-effective than screening by radiographic tests in average-risk populations. Also, the general population is more likely to prefer gastric cancer screening by endoscopy. Nonetheless, further study of the impact of endoscopy on gastric cancer mortality is needed, and future evaluations of screening methods should take into account cost and any associated reduction in gastric cancer mortality.

Conflicts of Interest

The authors have no financial conflicts of interest.

REFERENCES

1. Ferlay J, Soerjomataram I, Ervik M, et al. GLOBOCAN 2012 v1.0, Cancer Incidence and Mortality Worldwide: IARC CancerBase No. 11 [Internet]. Lyon: International Agency for Research on Cancer; c2014 [cited 2014 Apr 14]. Available from: <http://globocan.iarc.fr>.
2. Jemal A, Bray F, Center MM, Ferlay J, Ward E, Forman D. Global cancer statistics. *CA Cancer J Clin* 2011;61:69-90.
3. Jung KW, Won YJ, Kong HJ, Oh CM, Seo HG, Lee JS. Cancer statistics in Korea: incidence, mortality, survival and prevalence in 2010. *Cancer Res Treat* 2013;45:1-14.
4. Fukao A, Tsubono Y, Tsuji I, S HI, Sugahara N, Takano A. The evaluation of screening for gastric cancer in Miyagi Prefecture, Japan: a population-based case-control study. *Int J Cancer* 1995;60:45-48.
5. Mizoue T, Yoshimura T, Tokui N, et al. Prospective study of screening for stomach cancer in Japan. *Int J Cancer* 2003;106:103-107.
6. Hisamichi S, Sugawara N, Fukao A. Effectiveness of gastric mass screening in Japan. *Cancer Detect Prev* 1988;11:323-329.
7. Leung WK, Wu MS, Kakugawa Y, et al. Screening for gastric cancer in Asia: current evidence and practice. *Lancet Oncol* 2008;9:279-287.
8. Yoo KY. Cancer control activities in the Republic of Korea. *Jpn J Clin*

- Oncol 2008;38:327-333.
9. Hamashima C, Shibuya D, Yamazaki H, et al. The Japanese guidelines for gastric cancer screening. *Jpn J Clin Oncol* 2008;38:259-267.
 10. Yoshida M, Kondo K, Tada T. The relation between the cancer screening rate and the cancer mortality rate in Japan. *J Med Invest* 2010;57:251-259.
 11. Tashiro A, Sano M, Kinameri K, Fujita K, Takeuchi Y. Comparing mass screening techniques for gastric cancer in Japan. *World J Gastroenterol* 2006;12:4873-4874.
 12. Park CH. Proposal of a screening program for gastric cancer in Korea. *J Korean Med Assoc* 2002;45:964-971.
 13. Kim Y, Jun JK, Choi KS, Lee HY, Park EC. Overview of the National Cancer screening programme and the cancer screening status in Korea. *Asian Pac J Cancer Prev* 2011;12:725-730.
 14. Lee YY, Oh DK, Choi KS, Jung KW, Lee HY, Jun JK. The current status of gastric cancer screening in Korea: report on the National Cancer Screening Programme, 2009. *Asian Pac J Cancer Prev* 2011;12:3495-3500.
 15. National Cancer Center. *Cancer Facts & Figures 2014*. Goyang: National Cancer Center; 2014. 124p.
 16. Suh M, Choi KS, Lee YY, Jun JK. Trends in cancer screening rates among Korean men and women: results from the Korean National Cancer Screening Survey, 2004-2012. *Cancer Res Treat* 2013;45:86-94.
 17. Dan YY, So JB, Yeoh KG. Endoscopic screening for gastric cancer. *Clin Gastroenterol Hepatol* 2006;4:709-716.
 18. Liu CY, Wu CY, Lin JT, Lee YC, Yen AM, Chen TH. Multistate and multifactorial progression of gastric cancer: results from community-based mass screening for gastric cancer. *J Med Screen* 2006;13 Suppl 1: S2-S5.
 19. Lee YC, Wu HM, Chen TH, et al. A community-based study of Helicobacter pylori therapy using the strategy of test, treat, and re-test and re-test initial treatment failures. *Helicobacter* 2006;11:418-424.
 20. Lee YC, Chen TH, Chiu HM, et al. The benefit of mass eradication of Helicobacter pylori infection: a community-based study of gastric cancer prevention. *Gut* 2013;62:676-682.
 21. Pisani P, Oliver WE, Parkin DM, Alvarez N, Vivas J. Case-control study of gastric cancer screening in Venezuela. *Br J Cancer* 1994;69:1102-1105.
 22. Oshima A, Hirata N, Ubukata T, Umeda K, Fujimoto I. Evaluation of a mass screening program for stomach cancer with a case-control study design. *Int J Cancer* 1986;38:829-833.
 23. Abe Y, Mitsushima T, Nagatani K, Ikuma H, Minamihara Y. Epidemiological evaluation of the protective effect for dying of stomach cancer by screening programme for stomach cancer with applying a method of case-control study: a study of an efficient screening programme for stomach cancer. *Nihon Shokakubyo Gakkai Zasshi* 1995;92:836-845.
 24. Tsubono Y, Hisamichi S. Case-control studies of screening for gastric cancer in Japan. *J Gastroenterol Mass Surv* 1999;37:182-185.
 25. Inaba S, Hirayama H, Nagata C, et al. Evaluation of a screening program on reduction of gastric cancer mortality in Japan: preliminary results from a cohort study. *Prev Med* 1999;29:102-106.
 26. Lee KJ, Inoue M, Otani T, et al. Gastric cancer screening and subsequent risk of gastric cancer: a large-scale population-based cohort study, with a 13-year follow-up in Japan. *Int J Cancer* 2006;118:2315-2321.
 27. Miyamoto A, Kuriyama S, Nishino Y, et al. Lower risk of death from gastric cancer among participants of gastric cancer screening in Japan: a population-based cohort study. *Prev Med* 2007;44:12-19.
 28. Hamashima C, Ogoshi K, Okamoto M, Shabana M, Kishimoto T, Fukao A. A community-based, case-control study evaluating mortality reduction from gastric cancer by endoscopic screening in Japan. *PLoS One* 2013;8:e79088.
 29. Riecken B, Pfeiffer R, Ma JL, et al. No impact of repeated endoscopic screens on gastric cancer mortality in a prospectively followed Chinese population at high risk. *Prev Med* 2002;34:22-28.
 30. Hosokawa O, Miyayama T, Kaizaki Y, et al. Decreased death from gastric cancer by endoscopic screening: association with a population-based cancer registry. *Scand J Gastroenterol* 2008;43:1112-1115.
 31. Suguhara N, Shibuki S, Hirasawa Y, Morimoto T. Characteristics of false negative cases in gastric cancer mass survey. *Stomach Intest* 1991;26:1357-1362.
 32. Fukao A, Hisamichi S, Takano A, Sugahara N. Accuracies of mass screening for gastric cancer: test sensitivity and program sensitivity. *J Gastroenterol Mass Surv* 1992;97:59-63.
 33. Ishida T, Suematsu T, Oobayashi K, Takada Y, Kimura S, Suematsu C. Measurement of accuracy of stomach mass screening by population-based cancer registration. *J Gastroenterol Mass Surv* 1994;32:9-16.
 34. Hosokawa O. Transition in the diagnostic methods for gastric cancer and screening for gastric cancer. *J Gastroenterol Mass Surv* 1995;33:195-198.
 35. Abe S, Shibuya D, Noguchi T, Shimada T. An estimate of the false-negative rate of mass-screening for gastric carcinoma. *J Gastroenterol Mass Surv* 2000;38:475-482.
 36. Murakami R, Tsukuma H, Ubukata T, et al. Estimation of validity of mass screening program for gastric cancer in Osaka, Japan. *Cancer* 1990;65:1255-1260.
 37. Hosokawa O, Hattori M, Takeda T, Watanabe K, Fujita M. Accuracy of endoscopy in detecting gastric cancer. *J Gastroenterol Mass Surv* 2004;42:33-39.
 38. Otsuji M, Kouno Y, Otsuji A, Tokushige J, Shimotatara K, Arimura K. Assessment of small diameter panendoscopy for diagnosis of gastric cancer: comparative study with follow-up survey date. *Stomach Intest* 1989;24:1291-1297.
 39. Choi KS, Jun JK, Park EC, et al. Performance of different gastric cancer screening methods in Korea: a population-based study. *PLoS One* 2012;7:e50041.
 40. Hamashima C, Okamoto M, Shabana M, Osaki Y, Kishimoto T. Sensitivity of endoscopic screening for gastric cancer by the incidence method. *Int J Cancer* 2013;133:653-659.
 41. Gupta N, Bansal A, Wani SB, Gaddam S, Rastogi A, Sharma P. Endoscopy for upper GI cancer screening in the general population: a cost-utility analysis. *Gastrointest Endosc* 2011;74:610-624.
 42. Yeh JM, Hur C, Kuntz KM, Ezzati M, Goldie SJ. Cost-effectiveness of treatment and endoscopic surveillance of precancerous lesions to prevent gastric cancer. *Cancer* 2010;116:2941-2953.
 43. Zhou HJ, Dan YY, Naidoo N, Li SC, Yeoh KG. A cost-effectiveness analysis evaluating endoscopic surveillance for gastric cancer for populations with low to intermediate risk. *PLoS One* 2013;8:e83959.
 44. Lee YC, Lin JT, Wu HM, et al. Cost-effectiveness analysis between primary and secondary preventive strategies for gastric cancer. *Cancer Epidemiol Biomarkers Prev* 2007;16:875-885.
 45. Lee HY, Park EC, Jun JK, Choi KS, Hahm MI. Comparing upper gastrointestinal X-ray and endoscopy for gastric cancer diagnosis in Korea. *World J Gastroenterol* 2010;16:245-250.
 46. Chang HS, Park EC, Chung W, et al. Comparing endoscopy and upper gastrointestinal X-ray for gastric cancer screening in South Korea: a cost-utility analysis. *Asian Pac J Cancer Prev* 2012;13:2721-2728.
 47. Cho E, Kang MH, Choi KS, Suh M, Jun JK, Park EC. Cost-effectiveness outcomes of the national gastric cancer screening program in South Korea. *Asian Pac J Cancer Prev* 2013;14:2533-2540.
 48. Matsumoto S, Yamasaki K, Tsuji K, Shirahama S. Results of mass endoscopic examination for gastric cancer in Kamigoto Hospital, Nagasaki Prefecture. *World J Gastroenterol* 2007;13:4316-4320.
 49. Choi KS, Kwak MS, Lee HY, Jun JK, Hahm MI, Park EC. Screening for gastric cancer in Korea: population-based preferences for endoscopy versus upper gastrointestinal series. *Cancer Epidemiol Biomarkers Prev* 2009;18:1390-1398.
 50. National Cancer Center. *Support and Evaluation of National Cancer Control Program Report*. Goyang: National Cancer Center; 2014.
 51. Choi KS, Jun JK, Lee HY, et al. Performance of gastric cancer screening by endoscopy testing through the National Cancer Screening Program of Korea. *Cancer Sci* 2011;102:1559-1564.