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Review Article

Gastric Cancer Epidemiology in Korea

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Gastric cancer has been the most commonly diagnosed cancer in Korea although the age-standardized mortality and incidence has decreased gradually during last two decades. *Helicobacter pylori* infection and cigarette smoking are well-established risk factors, and the role of dietary factors, such as salted foods, fresh vegetables and fruits, soy foods, and processed or grilled meats on gastric carcinogenesis has been suggested. In this review, we review national and international gastric cancer statistics, studies on environmental risk factors conducted in the Korean population, and gastric cancer screening activities.

Key Words: Stomach neoplasms, Epidemiology, Incidence, Mortality, Risk factors

Introduction

Historically, gastric cancer has been one of the major cancers in East Asian countries like Korea and Japan. Although the mortality and incidence of gastric cancer has decreased in these regions, gastric cancer is still the fourth most common cancer in the world and the second most common cancer in Asia.(1) In this review, we first provide descriptive epidemiology of gastric cancer and then describe the literature on possible etiologic factors for gastric carcinogenesis. Most of gastric cancers are non-cardia cancer and only 4~5% of gastric cancers occur in the cardia.(2) The epidemiology of non-cardia and cardia gastric cancers differ. Therefore, we mainly focused on the environmental risk factors of non-cardia gastric cancer. Finally, the gastric cancer screening program is addressed.

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Gastric Cancer Incidence, Mortality, and Survival in Korea

Gastric cancer has been the most commonly diagnosed cancer in Korea since 1999 when the Korea Central Cancer Registry first reported nationwide cancer incidence data.(3) In females, gastric cancer was the most common incident cancer until 2001, and in 2008, it became the third most common incident cancer after thyroid cancer and breast cancer. However, gastric cancer has been the most common cancer in men in Korea since 1999 (3). In 2008, 28,078 new gastric cancer cases (18,898 male and 9,180 female) were diagnosed, accounting for 15.7% of all cancer occurrences. (3) Gastric cancer is relatively rare before age 30, and age-specific incidence rates increase as age advances (Table 1). Although not significant statistically, gastric cancer incidence has decreased in both males and females. The annual percentage changes in age-standardized gastric cancer incidence were −0.5% in males and −0.6% in females, respectively.(3)

Gastric cancer mortality decreased gradually between 1983 and 2009.(4) The crude mortality rates per 100,000 were 27.1 in males and 14.6 in females in 2008; these rates are expected to drop to 17.7 in males and 12.3 in females in 2011.(5) Fig. 1 showed the trend in gastric cancer incidence and mortality.

Table 1. Age-specific gastric cancer incidences in the Korea Central Cancer Registry, 1999 and 2008 (per 100,000 persons)(4)

Age group (years old)	Male		Female	
	1999	2008	1999	2008
0~4	0.1	0.0	-	0.0
5~9	0.1	0.0	-	0.0
10~14	-	0.1	-	0.0
15~19	0.3	0.2	0.3	0.1
20~24	1.2	0.7	1.5	1.0
25~29	4.1	2.6	5.6	4.1
30~34	9.5	7.3	11.1	11.0
35~39	23.1	16.7	17.4	16.4
40~44	38.9	36.3	23.2	28.8
45~49	67.8	66.6	31.5	37.2
50~54	119.1	121.3	44.6	46.5
55~59	196.0	192.5	67.9	65.2
60~64	299.2	276.2	96.9	86.9
65~69	391.0	378.3	143.7	120.6
70~74	486.4	472.9	189.0	160.8
75~79	561.2	534.5	220.1	183.0
80~84	540.2	500.7	214.0	183.2
85+	366.3	486.8	186.8	169.0

The 5-year survival rates for gastric cancer have dramatically increased from 43.0% in males and 42.6% in females who were diagnosed between 1993 and 1995 to 63.8% in males and 61.6% in females who were diagnosed between 2004 and 2008.(3) The improved survival may be explained by early diagnosis and advancements in treating gastric cancer.

International Comparison of Incidence and Mortality

Gastric cancer is the fourth most common cancer in the world behind lung, breast, and colorectal cancers and the second leading cause of cancer death worldwide after lung cancer.(1) About one million new cases were estimated to occur worldwide in 2008, with half occurring in East Asian countries alone, mainly in China.(1) Korea, Japan, Mongolia, and China showed the highest incidence rates, whereas mortality rates are highest in Mongolia, China, and central Asian countries such as Kyrgyzstan and Kazakhstan (Fig. 2). Although the incidence and mortality of gastric cancer are decreasing in most countries, the number of new cases and deaths from gastric cancer are expected to increase due to population aging.(1)

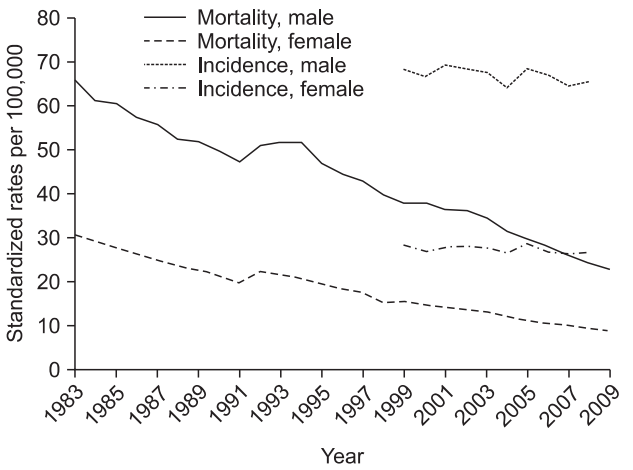

Fig. 1. Incidence (1999~2008) and mortality (1983~2009) of gastric cancer in Korea. Age standardization was performed using the middle year population of 2000 as a standard population (4).

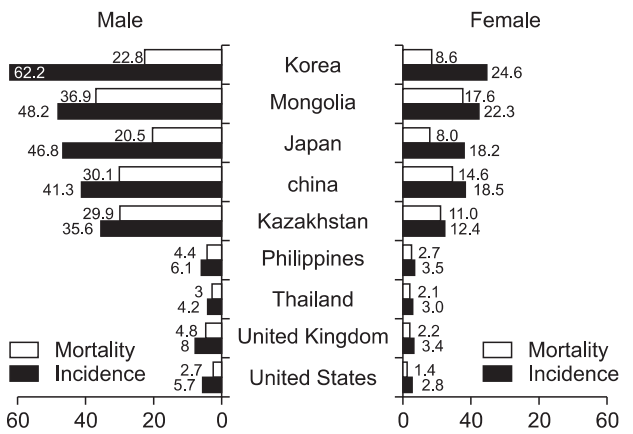

Fig. 2. Comparison of incidence and mortality of gastric cancer in selected countries with age-standardized rates per 100,000 using the World Health Organization world standard population (1).

Etiologic Factors

1. *Helicobacter pylori*

Helicobacter pylori (*H. pylori*) was been classified as a group 1 carcinogen for non-cardia gastric adenocarcinoma by the International Agency for Research on Cancer (IARC) in 1994.(6) Recently, the IARC reassessed the carcinogenicity of infectious agents, and low-grade B-cell mucosa-associated lymphoid tissue gastric lymphoma was added to cancer sites for which sufficient evidence of an association in humans exists for *H. pylori*.(7)

An international meta-analysis of 12 nested case-control studies on the *H. pylori* infection and risk of non-cardia gastric cancer reported a pooled relative risk of 3.0 for *H. pylori* seropositive subjects compared to negative subjects; the pooled relative risk was 5.9 in subjects followed for more than 10 years.(8) Five case-control

Table 2. Case-control studies on the association between *Helicobacter pylori* IgG seropositivity and gastric cancer risk in the Korean population

Authors (Year)	Study design	Sample size	Seropositivity in cases (%)	Seropositivity in controls (%)	Adjusted odds ratio (95% confidence interval)	Adjustment variables
Chang et al. (2001) (9)	Hospital-based case-control study	136 cases/ 136 controls	53	40	1.82 (1.10-3.00)	Age, sex, education, economic status
Lee et al. (2003)(12)	Hospital-based case-control study	69 cases/ 199 controls	88	75	5.3 (1.7-16.5)	Age, sex, education, family history of gastric cancer, smoking alcohol drinking
Shin et al. (2005)(13)	Nested case-control study in a community cohort	86 cases/ 344 controls	83.7	80.8	1.06 (0.80-1.40)	Education, alcohol drinking, smoking (matched for age, sex, residential area and year of recruitment)
Kim et al. (2005)(11)	Hospital-based case-control study	295 cases/ 295 controls	80.7	71.2	1.68 (1.14-2.44)	Age, sex, history of gastritis or ulcer, education
Cho et al. (2010)(10)	Hospital-based case-control study	2,819 cases/ 562 controls	84.7	66.7	3.13 (2.46-3.97)	Sex, smoking, drinking water, education, socioeconomic status during childhood

studies on the association between *H. pylori* and gastric cancer risk have been conducted in the Korean population.(9-13) Four studies were hospital-based case-control studies,(9-12) whereas one study was a nested case-control study within a community-based cohort.(13) A summary of these studies is presented in Table 2. In addition to *H. pylori* seropositivity, the CagA positive strain of *H. pylori* may more relevant to gastric carcinogenesis.(14) In addition, vitamin C intake may modify the relationship between *H. pylori* infection and gastric cancer risk because *H. pylori* seropositivity was found to be a significant risk factor for gastric cancer only among the low vitamin C intake group (OR=4.68 vs. OR=0.72 for the high vitamin C intake group).(11)

The *H. pylori* seroprevalence in the Korean population was 66.9% in 1998, dropping to 59.6% in 2005 in two consequent cross-sectional studies.(15) This decrease is likely due to an improvement in the socio-economic environment. In a study on the population-attributable fraction of infectious agents in Korean population, *H. pylori* infection was responsible for 80.3% of non-cardia gastric cancers in men and 78.7% in women.(2) Due to a decrease in the prevalence of *H. pylori*, the attributable fraction of the bacteria is expected to become smaller.

2. Cigarette smoking

Tobacco smoking has been classified as a group 1 carcinogen for gastric cancer by the IARC, indicating that sufficient evidence exists in humans.(16) Cigarette smoking is usually more prevalent among men, and three cohort studies conducted in Korea consistently showed an association between a longer duration of cigarette smoking and gastric cancer incidence (17,18) and mortality (19) in men. Men who smoked for 20~39 years had a 2.09-fold increased risk of gastric cancer compared to non-smokers, and those who smoked for more than 40 years had a 3.13-fold increased risk.(17)

In developing countries, 17% of gastric cancer in men and 11% in women were estimated to be attributed to tobacco smoking compared to 11% in men and 4% in women in developed countries.(20) In a Japanese cohort study, the estimated population attributable fraction of gastric cancer for cigarette smoking was 28.5%.(21) One Korean study on the burden of cancers due to smoking showed that gastric cancer causes 497.8 disability adjusted life years per 100,000 people, ranking gastric cancer highest among major cancers. The health adjusted life year per 100,000 men was 306.8 person-years behind the tracheal, lung, and bronchus cancers (489.7 person-years).(22)

3. Dietary factors

A summary of dietary factors associated with decreased or increased risk for gastric cancer is provided in Table 3.

1) Salt or salted food

The average daily salt intake in the Korean population was 13.4 g in 2005,(23) whereas the daily intake recommended by the World Health Organization is less than 5 g.(24) Ingestion of salt directly damages the stomach lining, enhancing the carcinogenic effects of gastric carcinogens, increasing nitroso compound formation, and facilitating *H. pylori* infection.(25) An ecological study on the association between sodium intake evaluated by 24-hour urine collection and gastric cancer mortality and incidence in four areas of Korea suggested a positive correlation between sodium intake and gastric cancer incidence and mortality.(26) A salt preference showed a 1.1-fold increased risk for gastric cancer in a cohort study of 2,248,129 subjects.(27)

Kimchi, which is allegedly believed to have anti-carcinogenic properties, accounts for approximately 20% of sodium intake.(23) Case-control studies on the intake level of kimchi and gastric cancer risk generally showed an increased risk among subjects with high or frequent intakes of kimchi.(28-30) In addition, a high intake of soybean paste (28) or frequent intake of soybean paste stew (31) increased the risk of gastric cancer.

2) Vegetables and fruits

An increase in the consumption of fresh vegetables and fruits and the resultant decrease in preserved vegetables have been suggested to account for rapid decreases in gastric cancer mortality.(32) The putative mechanisms of the protective effect of fresh vegetables have been suggested to be attributed to their high antioxidant nutrient concentrations, such as vitamin C, carotenoids, and vitamin E compound, dietary fiber, and phytoestrogens.(25) In a meta-analysis of observational studies conducted in Korea and Japan concerning the relationship between fresh and pickled vegetable consumption and gastric cancer, a high intake of fresh vegetables was associated with a decreased risk of gastric cancer (summary odds ratio=0.62, 95% CI=0.46~0.85), whereas a high intake of pickled vegetables was associated with an increased risk of gastric cancer (summary odds ratio=1.28, 95% CI=1.06~1.53).(33)

3) Soy and soy products

Soy and soy products are important sources of phytoestrogens, which possesses weak estrogenic activity and act as an estrogen antagonist, have been linked to breast, prostate, and colon cancer prevention.(34) Two case-control studies reported a decreased risk for gastric cancer with high intake of soybean curd (tofu).(29,31) A meta-analysis of observational studies conducted in Korea and Japan reported that a high intake of fermented soy foods was associated with an increased risk of gastric cancer (odds ratio=1.22, 95% CI=1.02~1.44), whereas an increased intake of non-fermented soy foods was significantly associated with a decreased risk of gastric cancer (odds ratio=0.64, 95% CI=0.54~0.77).(35) In a nested case-control study with 131 gastric cancer cases and 393 age- and sex-matched controls, the median plasma concentrations of genistein and daidzein, the two important isoflavones were lower in the case group than in the control group, suggesting a protective effect of high soy product intake for gastric cancer.(36)

4) Processed meats and cooking methods

Nitrates used as preservatives in processed meats are also produced endogenously in gastric acid. These contribute to N-nitroso compound production, which are suspected carcinogens.(37) In addition, high-temperature cooking of meat generates mutagens such as heterocyclic amines and polycyclic aromatic hydrocarbons.(38) Charcoal grilled beef (30) or broiled meat and fish consumption (31)

Table 3. Food, nutrition and gastric cancer risk (modified from WCRF/AICR, 2007) (25)

	Decreases risk	Increases risk
Convincing	-	-
Probable	Non-starchy vegetables	Total salt consumption
	Allium vegetables	Salted and salty foods
	Fruits	
Limited-suggestive	Pulses (legumes) including soya and soya product	Chili
		Processed meat
	Foods containing selenium	Smoked foods
		Grilled (broiled) or barbecued (charbroiled) animal foods

were associated with an increased risk for gastric cancer, whereas total meat consumption was not associated with gastric cancer risk (30) in case-control studies.

Gastric Cancer Screening

The National gastric cancer screening program was introduced in 1999 as a part of the National Cancer Screening Program (NCSP), providing gastric cancer screening to Medical Aid recipients free of charge.(39) Since 2005, the target population of the NCSP expanded to include the National Health Insurance (NHI) beneficiaries within the lower 50% of the income bracket. Since 2010, for the upper 50% of NHI beneficiaries, 90% of the funds for gastric cancer screenings are supported by the NHI, and 10% is paid by the participants.(40) The participation rate increased from 11.4% in 2002 to 29.2% in 2008.(40) However, participation rates are higher when screenings conducted outside the NCSP are considered. The annual National Cancer Screening Survey reported gastric cancer screening rates of 39.2% in 2004 increasing to 56.9% in 2009.(40) The sensitivity of endoscopy among participants who underwent the NCSP from 2002 to 2005 was 69%, and the sensitivity was higher for the detection of regional or distant gastric cancers than localized tumors.(41)

Conclusions

Gastric cancer incidence and mortality are decreasing gradually; however, the absolute number of new cases and deaths from gastric cancer are expected to grow due to rapid population aging.(5) For primary prevention, smoking cessation and healthy dietary habits with adequate fresh vegetable and limited salt intake are recommended. For secondary prevention, improvement and maintenance of the screening program quality, as well as efforts to increase participation rate, are required.

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References

1. http://globocan.iarc.fr/Accessed July 29, 2011.
2. Shin A, Park S, Shin HR, Park EH, Park SK, Oh JK, et al. Population attributable fraction of infection-related cancers in Korea. Ann Oncol 2011;22:1435-1442.
3. Jung KW, Park S, Kong HJ, Won YJ, Lee JY, Park EC, et al. Cancer statistics in Korea: incidence, mortality, survival, and prevalence in 2008. Cancer Res Treat 2011;43:1-11.
4. http://www.kosis.kr/Accessed July 21, 2011
5. Jung KW, Park S, Won YJ, Kong HJ, Lee JY, Park EC, et al. Prediction of cancer incidence and mortality in Korea, 2011. Cancer Res Treat 2011;43:12-18.
6. World Health Organization International Agency for Research on Cancer. Schistosomes, Liver Flukes and *Helicobacter pylori*. In: IARC Monographs on the Evaluation of Carcinogenic Risks to Humans. Lyon: International Agency for Research on Cancer, 1994.
7. Bouvard V, Baan R, Straif K, Grosse Y, Secretan B, El Ghissassi F, et al; WHO International Agency for Research on Cancer Monograph Working Group. A review of human carcinogens--Part B: biological agents. Lancet Oncol 2009;10:321-322.
8. Helicobacter and Cancer Collaborative Group. Gastric cancer and *Helicobacter pylori*: a combined analysis of 12 case control studies nested within prospective cohorts. Gut 2001;49:347-353.
9. Chang WK, Kim HY, Kim DJ, Lee J, Park CK, Yoo JY, et al. Association between *Helicobacter pylori* infection and the risk of gastric cancer in the Korean population: prospective case-controlled study. J Gastroenterol 2001;36:816-822.
10. Cho SJ, Choi IJ, Kim CG, Lee JY, Kook MC, Seong MW, et al. *Helicobacter pylori* seropositivity is associated with gastric cancer regardless of tumor subtype in Korea. Gut Liver 2010;4:466-474.
11. Kim DS, Lee MS, Kim YS, Kim DH, Bae JM, Shin MH, et al. Effect modification by vitamin C on the relation between gastric cancer and *Helicobacter pylori*. Eur J Epidemiol 2005;20:67-71.
12. Lee SA, Kang D, Shim KN, Choe JW, Hong WS, Choi H. Effect of diet and *Helicobacter pylori* infection to the risk of early gastric cancer. J Epidemiol 2003;13:162-168.
13. Shin A, Shin HR, Kang D, Park SK, Kim CS, Yoo KY. A nested case-control study of the association of *Helicobacter pylori* infection with gastric adenocarcinoma in Korea. Br J Cancer 2005;92:1273-1275.
14. Gwack J, Shin A, Kim CS, Ko KP, Kim Y, Jun JK, et al. CagA-producing *Helicobacter pylori* and increased risk of gastric cancer: a nested case-control study in Korea. Br J Cancer 2006;95:639-641.
15. Yim JY, Kim N, Choi SH, Kim YS, Cho KR, Kim SS, et al. Sero-

prevalence of *Helicobacter pylori* in South Korea. Helicobacter 2007;12:333-343.
16. Secretan B, Straif K, Baan R, Grosse Y, El Ghissassi F, Bouvard V, et al; WHO International Agency for Research on Cancer Monograph Working Group. A review of human carcinogens--Part E: tobacco, areca nut, alcohol, coal smoke, and salted fish. Lancet Oncol 2009;10:1033-1034.
17. Kim Y, Shin A, Gwack J, Jun JK, Park SK, Kang D, et al. Cigarette smoking and gastric cancer risk in a community-based cohort study in Korea. J Prev Med Public Health 2007;40:467-474.
18. Yun YH, Jung KW, Bae JM, Lee JS, Shin SA, Park SM, et al. Cigarette smoking and cancer incidence risk in adult men: National Health Insurance Corporation Study. Cancer Detect Prev 2005;29:15-24.
19. Jee SH, Samet JM, Ohrr H, Kim JH, Kim IS. Smoking and cancer risk in Korean men and women. Cancer Causes Control 2004;15:341-348.
20. Parkin DM, Pisani P, Ferlay J. Estimates of the worldwide incidence of eighteen major cancers in 1985. Int J Cancer 1993;54:594-606.
21. Shikata K, Doi Y, Yonemoto K, Arima H, Ninomiya T, Kubo M, et al. Population-based prospective study of the combined influence of cigarette smoking and *Helicobacter pylori* infection on gastric cancer incidence: the Hisayama Study. Am J Epidemiol 2008;168:1409-1415.
22. Lee H, Yoon SJ, Ahn HS. Measuring the burden of major cancers due to smoking in Korea. Cancer Sci 2006;97:530-534.
23. Report on National Health and Nutritional Examination, 1969-2005. Ministry of Health and Welfare 2007.
24. WHO/FAO Expert Consultation, ed. Diet, Nutrition and the Prevention of Chronic Diseases. 2003 WHO Technical Report Series No. 916. Geneva, Switzerland: World Health Organization, 2003.
25. World Cancer Research Fund, American Institute for Cancer Research, eds. Food, Nutrition, Physical Activity, and the Prevention of Cancer: a Global Perspective. Washington DC: World Cancer Research Fund, 2007.
26. Park B, Shin A, Park SK, Ko KP, Ma SH, Lee EH, et al. Ecological study for refrigerator use, salt, vegetable, and fruit intakes, and gastric cancer. Cancer Causes Control 2011 Jul 30. [Epub ahead of print].
27. Kim J, Park S, Nam BH. Gastric cancer and salt preference: a population-based cohort study in Korea. Am J Clin Nutr 2010;91:1289-1293.
28. Nan HM, Park JW, Song YJ, Yun HY, Park JS, Hyun T, et al. Kimchi and soybean pastes are risk factors of gastric cancer. World J Gastroenterol 2005;11:3175-3181.
29. Lee S, Kang D, Hong WS, Shim KN, Choe JW, Choi H. Dietary habit and *Helicobacter pylori* infection in early gastric cancer patient. Cancer Res Treat 2002;34:104-110.
30. Kim HJ, Chang WK, Kim MK, Lee SS, Choi BY. Dietary factors and gastric cancer in Korea: a case-control study. Int J Cancer 2002;97:531-535.
31. Lee JK, Park BJ, Yoo KY, Ahn YO. Dietary factors and stomach cancer: a case-control study in Korea. Int J Epidemiol 1995;24:33-41.
32. Kono S, Hirohata T. Nutrition and stomach cancer. Cancer Causes Control 1996;7:41-55.
33. Kim HJ, Lim SY, Lee JS, Park S, Shin A, Choi BY, et al. Fresh and pickled vegetable consumption and gastric cancer in Japanese and Korean populations: a meta-analysis of observational studies. Cancer Sci 2010;101:508-516.
34. Messina MJ, Persky V, Setchell KD, Barnes S. Soy intake and cancer risk: a review of the in vitro and in vivo data. Nutr Cancer 1994;21:113-131.
35. Kim J, Kang M, Lee JS, Inoue M, Sasazuki S, Tsugane S. Fermented and non-fermented soy food consumption and gastric cancer in Japanese and Korean populations: a meta-analysis of observational studies. Cancer Sci 2011;102:231-244.
36. Ko KP, Park SK, Park B, Yang JJ, Cho LY, Kang C, et al. Isoflavones from phytoestrogens and gastric cancer risk: a nested case-control study within the Korean Multicenter Cancer Cohort. Cancer Epidemiol Biomarkers Prev 2010;19:1292-1392.
37. Goldman R, Shields PG. Food mutagens. J Nutr 2003;133(Suppl 3):965S-973S.
38. Sinha R, Rothman N. Exposure assessment of heterocyclic amines (HCAs) in epidemiologic studies. Mutat Res 1997;376:195-202.
39. Yoo KY. Cancer control activities in the Republic of Korea. Jpn J Clin Oncol 2008;38:327-333.
40. 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.
41. Choi KS, Jun JK, Lee HY, Park S, Jung KW, Han MA, et al. Performance of gastric cancer screening by endoscopy testing through the National Cancer Screening Program of Korea. Cancer Sci 2011;102:1559-1564.