Assessment of the Fear of COVID-19 and its Impact on Cancer Screening Participation among the Korean General Population

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ABSTRACT

Assessment of the fear of COVID-19 and its impact on cancer screening participation among the Korean general population

The decline in cancer screening has been reported since the beginning of the novel coronavirus disease (COVID-19) crisis. The consequences could be delays in cancer diagnosis and increase in the proportion of advanced stages, which may eventually lead to dreadful effect on cancer mortality. Fear of contracting virus has been suggested in several reports to explain the disruption in cancer secondary prevention even after major waves of COVID-19, however studies done to assess the fear of COVID-19 in target screening population are scarce and how much it influences their screening behaviors during the pandemic remains unclear. This study aimed to assess the excess fear towards COVID-19 and quantify its effect on cancer screening behaviors in a representative sample of the general public who were targeted in cancer screening programs. We examined one specific psychological aspect – fear of COVID-19 in comparison with cancer – as hypothesized that people tended to weigh their fear of having a relevant disease compared with that of coronavirus infection, affecting their decisions to undergo or postpone screening.

The Korean National Cancer Screening Survey (KNCSS) was a population-based,

cross-sectional survey using a structured questionnaire, conducted annually since 2004 by the Korea National Cancer Center to investigate cancer screening rates of five major malignancies (gastric, liver, colorectal, breast, and cervix). We extracted data on 3557 cancer-free respondents aged from 40 to 74 years in 2020, including sociodemographic characteristics, residential area, smoking status, comorbidities, family history of cancer, self-perceived general health status, attitudes towards participating in screening, and the fear of COVID-19 in comparison with cancer. We collected the information on their participation in cancer screening and general health check-ups during the pandemic and analyzed the participation rate according to the degree of fear of COVID-19. Logistic regression was applied to assess the association between the COVID-19 fear and screening uptake, and the findings consistency was explored by sensitivity analysis.

Among 3557 respondents, 1197 (33.65%) people were more fearful of COVID-19 than cancer, and 1066 (29.97%) were more fearful of COVID-19 than lung cancer. 2392 (67.25%) did not participate in health check-ups, of which 573 (24.0%) had a schedule for health check-ups but did not receive. Regarding our main interest, we observed a significant increase in the proportion of non-participation in pre-scheduled health check-ups when the fear of COVID-19 exceeds cancer/ lung cancer. In multivariable logistic analysis, the respondents with more fear of COVID-19 compared with cancer showed decreased likelihood of attendance in gastric cancer screening (OR, 0.81; 95% CI, 0.66-0.98), breast cancer screening (OR, 0.88; 95% CI, 0.67-1.16) and cervical cancer screening (OR, 0.76; 95% CI,

0.61-0.95). The odds of participation in health check-ups were also lower in those perceived more fear of COVID-19 compared with cancer (OR, 0.91; 95% CI, 0.77-1.05) and lung cancer (OR, 0.82; 95% CI, 0.70-0.96). Sensitivity analysis did not change our overall findings.

Our study revealed a considerable proportion of the general population perceived more fear of COVID-19 than cancer, which significantly hampered their engagement in regular medical check-ups including cancer screening. This finding highlights the need for providing appropriate information amid the ongoing pandemic, particularly for high-risk individuals targeted in cancer screening to minimize disruption in cancer prevention activities.

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1.1. COVID-19 pandemic and psychological impact

1.1.1. The COVID-19 pandemic

A novel virus named severe acute respiratory syndrome coronavirus 2 (SARS-Cov-2) was discovered from a cluster of severe pneumonia in Wuhan, China in December 2019. A few weeks later, the World Health Organization (WHO) announced this outbreak of infection termed Coronavirus Disease 2019 (COVID-19) as a Public Health Emergency of International Concern.[1] SARS-CoV-2, which belongs to coronaviruses (CoVs) family known since 1960s, contains a single stranded, enveloped positive sense RNA (ssRNA) and spreads similarly to other coronaviruses. Person-to-person transmission occur via droplets produced by coughing or sneezing, by personal contact or touching contaminated surfaces.[2] The majority of infected people have mild to moderate symptoms (such as cough, fever, tiredness) that will go away without special treatment or hospitalization, some others have no symptoms at all. In few other cases, however, the virus can cause pneumonia, respiratory failure, heart problems, liver issues, and death. People in their older ages or having underlying medical conditions such as cardiovascular disease, chronic respiratory disease, diabetes, and cancer are placed at higher risk to develop more serious complications.[3] Pneumonia caused by SARS-CoV-2 poses a persistent concern all throughout the world. With unique replication mechanism, coronavirus has high rate of recombination and mutation, making it easier to adapt

to new hosts and ecological niches. Moreover, it has longer incubation period (ranges from 0 to 24 days) than other coronaviruses which poses higher risk of virus spreading.[4]

Despite several efforts in inhibiting virus transmission, COVID-19 has spread at an unprecedented rate to at least 114 countries with approximately 118,000 cases and resulted in more than 4,000 deaths by March 2020. On March 11 2020, WHO officially declared COVID-19 a pandemic.[5] In South Korea, after the first confirmed COVID-19 patient on January 20th of 2020, the number of cases went on its peak (daily number of 909 cases on Feb 29th 2020) due to the large outbreak linked to Shincheonji Church of Jesus religious meetings,[6] ranking the country as the world's second most hit by the pandemic in late February. However, authorities have successfully flattened the curve in a timely manner by proactive and drastic strategies including massive testing and tracing through innovative measures and transparent risk communication.[7] As of 30 April 2020, South Korea has recorded 10,765 confirmed cases and 247 deaths which 92% of these occurred among people aged over 60 years. The country then has experienced 2 more waves of COVID-19, the later one led to a peak daily case count of over 1,000 at the end of 2020 before dropping in January 2021. On 31st December 2020, South Korea reported a total of 60,738 confirmed cases and 900 deaths.[8]

To date, COVID-19 has been rapidly spreading in about 213 countries, area, or territories. Researchers from all around the globe are continuously working on epidemiology, prevention, diagnosis, and treatment of the COVID-19. Vaccines are now approved to prevent infection and also to prevent serious complications,

hospitalization and death from COVID-19 among those who are infected. On the other hand, different SARS-CoV-2 variants have emerged, and one of them was called the Delta variant.[9] This was considered a "variant of concern" by the CDC and becoming the most contagious strain of the SARS-CoV-2 coronavirus to date. Not only it can spread faster than earlier forms of SARS-CoV-2, but the Delta variant may also cause more severe symptoms in unvaccinated people.

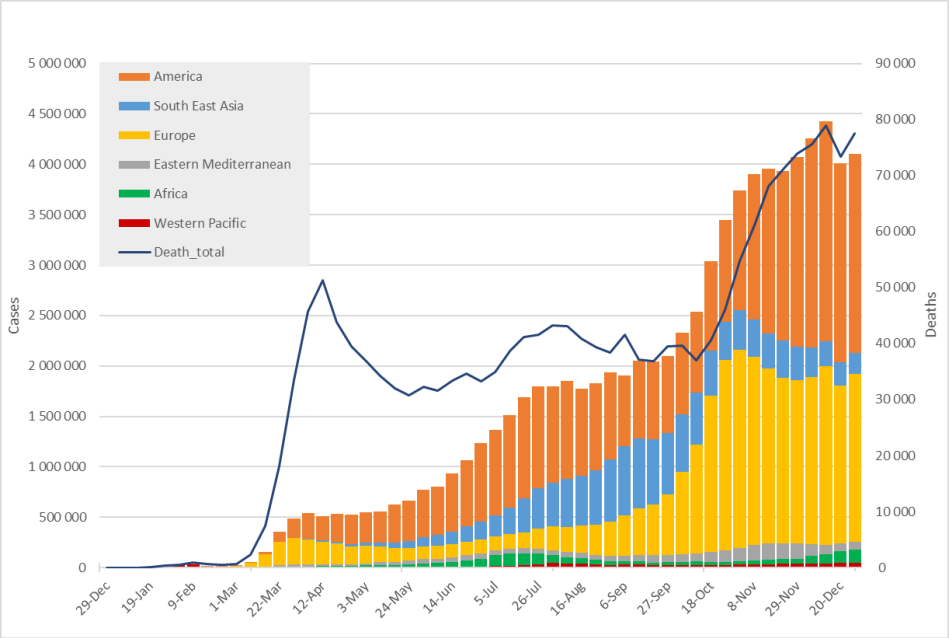

Figure 1. 1 COVID-19 confirmed cases and deaths by region according to the WHO as of 27st December 2020 (adapted from WHO Weekly epidemiological update [10]).

1.1.2. Social, economic, and psychological impact

In response to the COVID-19 crisis, prolonged lockdown, tight restrictions on gathering and travel have been imposed with numerous warning messages through broadcasts in effort to reduce disease transmission, which inevitably

contributed to undesirable social and economic influences.[11] Social distancing and travel restrictions have resulted in a reduction in the workforce across all economic sectors and the loss of many employment. Schools have closed down; non-critical business operations went disrupted or bankrupt. While demand and consumption of products and services have decreased, the need for medical supplies has grown substantially with the surge of COVID-19 patients, leaving several hospitals in a state of chaos, as they have reached their maximum capacity. The food sector also experienced growing demand as people trying to stock up on food products.

Besides, many people underwent self-quarantine, social isolation, disconnection with friends and family, resulting in more than ever feelings of helplessness, frustration, boredom, anxiety, and depression. Meanwhile, the massive use of technology and social media during this time has raised a concern of infodemic where mis- and disinformation of COVID-19 are being transported with broad coverage and may cause harm to people's physical and mental health. Since the initial phase, the pandemic has been found to be linked with a noteworthy rise of psychiatric and mental health issues worldwide.[12,13] The United Nations emphasized that the COVID-19 pandemic is threatening not only physical health, but psychological suffering.[14]

A large-scaled systematic review and meta-analysis by Cénat JM et al reported three to five times higher prevalence of anxiety, depression and post-traumatic stress disorders (PTSD) in the pandemic-affected populations, compared with the general public under normal state.[15] Prevalence rates of insomnia and

psychological distress were also significantly higher than those usually seen in the community. As for medical personnel, physicians and nurses are put under extreme pressure at work to diagnose and treat infected patients, thus placing them at higher risk of not only acquiring the new virus but also suffering from serious mental issues. Indeed, they experienced significantly higher prevalence of anxiety, depression and particularly, insomnia.[16]

The prolonged pandemic also turns people with underlying chronic diseases into high-risk groups by not being received adequate medical treatment for their conditions and being subjected to higher risks of mental health problems.[16] This was most likely due to the fact that during the peak of the COVID-19 epidemic, people were strongly encouraged to avoid attending hospital. Furthermore, fear and worries about a new dangerous pathogen seemed to continuously hamper their engagement in health examinations and compliance with treatment,[17] resulting in noticeable canceled visits and inappropriate adherence to therapy among patients.[18,19] Fear of COVID-19 might involve several aspects apart from the worry of rapid transmission and disease severity, including the fear of being stigmatized or discriminated, social isolation, fear related to infection risks of loved-ones, and loss of job or money. In addition, many people tended to weigh their fear of having a particular disease and coronavirus infection, which contributed as an important factor in deciding whether to attend health screening.[20,21] How people perceive regarding their own risk of developing a particular disease and risk of virus infection, however, was still unclear.

Thus, as previously seen after novel disease outbreaks and natural disasters, mental health problems are increasing in a variety of populations and are continued to spread along with the prolonged COVID-19 pandemic. More attentions should be paid in addressing this collateral effect of COVID-19 and tackling its impact on overall human well-being.

1.1.3. COVID-19 and deaths from other causes

While we are concerning about the increasing number of cases and deaths from coronavirus infection, studies have also revealed a substantial lift in deaths from other chronic and severe acute disorders. The UK Office for National Statistics (ONS) reported over 12,000 excess non-covid deaths in 2020, compared with the previous 5-year average.[22] In the US, although number of deaths was surprisingly constant, it climbed by 20% during March-July 2020, especially high in certain states such as up to 65% in New York.[23] Only 67% of these excess deaths were linked to COVID-19, the rest was suspectedly attributed to some noninfectious causes increased during COVID-19 surges such as heart disease, Alzheimer disease/ dementia. In fact, excess deaths might reflect deaths from undiagnosed or undocumented infection with coronavirus (under-reporting) or deaths from acute/ chronic conditions not receiving adequate healthcare due to disruptions brought by the pandemic. Public health surveillance for each specific disease with critical insight should be given special attention to guide control measures and health services planning amid the chaos of the pandemic.

1.2. Cancer Screening Program before and during the COVID-19 pandemic

1.2.1. Cancer burden

Cancer has been a rising public health and economic burden. Worldwide in 2020, approximately 50.5 million persons are living with cancer who had been diagnosed within the previous 5 years. Also in 2020, reports showed around 19.3 million cases and 10 million deaths from cancer (including non-melanoma skin cancers), with approximately one out of every four men and one out of every five women developing cancer, and one out of every eight men and one out of eleven women dying from it.[24] The number of new cancer cases is expected to climb from 18.1 million in 2018 to 29.4 million in 2040 as a result of aging and population growth. Asia is now home to half of the world's new cases and deaths. With an estimated 2.3 million new cases (11.7%), breast cancer has overtaken lung cancer to become the most commonly diagnosed malignancy, followed by lung, colorectal, prostate, and stomach cancers. Lung cancer remained the top cause of cancer mortality with about 1.8 million deaths (18%), followed by colorectal, liver, stomach, and breast cancers.[24]

In South Korea, lung, stomach, breast and stomach cancer are among the most common cancer types. Cancer was also the leading cause of death, accounting for 27.6% of all deaths in 2017,[25] in which lung cancer ranked the first with 17,980 deaths and remains the most common and leading cause of cancer death till 2020.[26] The high mortality rate is related to the fact that many individuals are not diagnosed

until their disease has progressed to the point where treatment options are limited and prognosis is poor. Early detection is therefore critical for better outcomes and survival. Table 1.1 provides a glance at the burden of different cancers in 2018, compared with COVID-19 cases and deaths occurred in South Korea in 2020.

Table 1. 1 Burden from COVID-19 compared with cancer in South Korea*

	Number of new cases	Number of deaths	Case fatality rate (%)
COVID-19 (2020)	60738	900	1.48
All cancers (2018)	243837	80747	33.12
Lung cancer (2018)	28628	17852	62.36
Liver cancer (2018)	15736	10611	67.43
Colorectal cancer (2018)	27909	8786	31.48
Stomach cancer (2018)	29279	7746	26.46
Breast cancer (2018)	23647	2473	10.46
Cervical cancer (2018)	3500	845	24.14

**Latest cancer statistic in 2018 was taken from kosis.kr*

1.2.2. Current cancer screening guidelines

Screening nowadays has been made available for cancer of the cervix, breast, prostate, liver, colorectum, stomach, and the latest - lung cancer. Apart from the ability to detect cancer at early stages, and thus improving survival and reducing deaths, some cancers can also be prevented by screening, identifying, and removing its precursors, such as Papanicolaou (Pap) smears for cervical cancer and endoscopic screening for colorectal cancer.

Cancer screening is now provided under two forms: opportunistic and organized. Opportunistic screening was the direct requests from individuals or their health advisor, whereas organized screening involves invitation letters being issued from the government or public health sector and sent out to the screening target population. Thus, screening participation with opportunistic strategy depends on the frequency of clinic visits or the provision of screening recommendations from physicians, resulting in a smaller population covered and less accessibility for disadvantaged groups who are at higher risk of developing the disease. On the other hand, in most organized screening programs, letters of invitation are used to contact and encourage the targeted individuals to undergo screening, apart from other promotions such as small media (brochures, ads) and mass media (radio advertisements, bus stop advertisements). An invitation letter contains low-literacy printed messages, often describing the benefits of screening and advising people to receive regular screenings. Several evidence have shown that organized screening strategy with personalized invitation offers greater benefits in terms of maximizing population coverage, minimizing screening harms

and improving screening adoption.[27-29]

In South Korea, both opportunistic and organized cancer screening strategies are under operation. At the national population level, the Korea National Cancer Screening Program (KNCSP),[30] first launched in 1999, has been expanded to target five major malignancies of the stomach, uterine cervix, breast, colorectum and liver. Annual lung cancer screening by low dose computed tomography (LDCT) has recently been added for high-risk groups (aged 55 to 74 years with smoking history of 30 pack-years or more).[31] Besides, screening interval for liver cancer has been shortened from a year to six months, and the recommended starting age for cervical cancer screening has changed from 30 to 20 years old (Table 1.2).

Table 1. 2 Current Korea National Cancer Screening Program (KNCSP).[32]

	Target population	Frequency	Test or Procedure
Stomach	40y & over	Every 2 years	Upper Gastro-Intestinography (UGI) or Gastrointestinal Endoscopy (biopsy)
Liver	40y & over with high risk group*	Every 6 months	Abdominal Ultrasonography + Serum Alpha-Fetoprotein test (Combined)
Colorec-tum	50y & over	Annually	(1st test) Fecal occult blood test (FOBT) (2nd test) Colonoscopy (biopsy) or Double Contrast Barium Enema
Breast	Women aged 30y & over	Annually	Breast self-examination
	Women aged 40y & over	Every 2 years	Mammography
Cervix Uteri	Women aged 20y & over	Every 2 years	Pap smear
Lung	55y to 74y - high risk group**	Annually	Low-dose computed tomography (LDCT)

** 40 & over with HBsAg positive or anti-HCV positive or liver cirrhosis*

*** Started from 2019 for those with ≥ 30 pack-year smoking history and currently smoke or have quit within the past 15 years*

Gastric cancer screening

Almost half of gastric cancer incidence now occurred in East Asia, particularly in China, Japan and Korea – where population-based gastric cancer screening has been implemented. The most commonly used screening method is upper endoscopy, which helps visualize the gastric mucosa and collect biopsies for the diagnosis of precancerous lesions such as gastric atrophy, intestinal metaplasia, or gastric dysplasia in addition to gastric cancer. Although this procedure may be expensive and invasive, it is valued by the higher sensitivity for identifying gastric lesions compared with other methods. A meta-analysis of 10 Asian studies has reported a 40% reduction (RR=0.6, 95% CI, 0.49-0.73) in gastric cancer mortality for endoscopic screening.[33]

In Japan, where gastric cancer used to be the leading cause of death from cancer, gastric cancer screening using photofluorography (via indirect upper-gastrointestinal series) has been introduced for all people aged ≥ 40 years since 1983 under the Health Service Law for the Aged.[34] Currently, endoscopy screening was also recommended every 2 or 3 years for those aged ≥ 50 years.[35] In China, the current national gastric screening program with endoscopy is focusing on high-risk individuals aged 40−69 years in selected areas.[36]

In South Korea, population-based gastric cancer screening was implemented since 2002 as a part of the KNCSP, targeted people aged ≥40 years for biennial screening by either upper gastrointestinal series (UGIS) or endoscopy (depending on individual's preference).[37] A Korean study has shown the effectiveness of this

program in reducing mortality of gastric cancer by using endoscopy but not UGIS.[38] This study also found a statistically significant inverse dose-response relationship between the number of endoscopy performed and gastric cancer mortality. The KNCSP for gastric cancer could also lower esophageal cancer mortality, for which upper endoscopy performed better than UGIS when it consistently reduced mortality rate in all age groups over 50 years, but UGIS could not.[39] Screening rates with recommendations for gastric cancer have increased from 39.2% in 2004 to 72.8% in 2018, in which the rate of those underwent upper endoscopy went up to 64.7%, while the rate of UGI series stayed at only 24.9% in 2018.[40]

Breast cancer screening

Breast cancer is now the most common cancer diagnosed in women of many developed countries while its incidence is continued to increase. Mammography (the low-dose x-rays of the breast) was the only form of breast imaging that consistently has been proven to reduce breast cancer mortality in numerous randomized trials, therefore became the primary screening modality for breast cancer. Other screening methods such as ultrasound and magnetic resonance imaging (MRI) are used for diagnostic follow-up after abnormal results of mammography or to screen women who are at a greater risk of breast cancer. Different types of mammography are available for choice: screen-film mammography, digital mammography, and digital breast tomosynthesis (3D mammography). With higher sensitivity, digital mammography or digital breast tomosynthesis is usually preferred for screening in women with dense breasts.

Screening ultrasound can also be used as an adjunct to mammography for women with increased breast density.

Screening interval recommendations for breast cancer varies from one to three years, depending mostly on the age of target population. Women aged between 50 and 70 years in the UK are recommended to undergo mammography screening every 3 years by the National Health Service; screening rate in total was 71.1% in 2018-2019.[41] In the US, there is no centrally organized breast cancer screening program, and the US Preventive Services Task Force recommended biennial mammography screening for women aged 50–74 years, while women aged 40—49 years are advised to talk with their physician about breast cancer risk factor before initiating screening.[42] Other recommendations in the US slightly differ in starting ages and screening interval. Screening rates have went up to around 67% in 2018.[43]

Korean women aged from 40 years are advised to undergo mammography screenings every 2 years under the KNCSP. The KNCSP has been shown to be effective in reducing breast cancer mortality (mortality rate ratio of screened and non-screened women: MRR = 0.43; 95% CI = 0.41-0.44), with greatest reduction in women aged 45-54 yeasr.[44] The adherence rate to breast cancer screening recommendation increased from 33.2% in 2004 to 63.1% in 2018.[40]

Cervical cancer screening

Cervical cancer screening has important benefits in detecting precancerous lesions of the cervix, thus allows effective early treatment before cancer develops and substantially reduce cervical cancer incidence and mortality. Common

screening methods are cervical cytology (or Pap test) and human papillomavirus (HPV) testing, using either alone or in combination (co-test). Results from these tests then are utilized to guide further assessment such as repeating cytology, perform colposcopy, biopsies, or excision.

Conventional pap smears are performed by smearing the specimen on a slide, while in liquid-based methods, the specimen is placed in a liquid fixative solution. In both methods, cells are obtained from the external surface of the cervix and the cervical canal to evaluate the transformation zone - the area at greatest risk for neoplasia. The conventional smear has advantages of a simple, low-cost procedure with high specificity, however subjects to high false-negative rate caused by sampling errors, low reproducibility, and subjective interpretation by well-trained cytologists. On the other hand, liquid-based systems have advantages of better sampling and ability to use a single specimen for multiple testing (such as both cytology and HPV test). HPV testing is considered useful to complement the low sensitivity of the Pap test, by identifying some most common high-risk oncogenic subtypes associated with cervical cancer and precancer, typically HPV 16 and 18. Although this method is increasingly available for screening in many countries, its low specificity yields many patients undergoing unnecessary colposcopy and biopsy, and its sensitivity and cost-effectiveness vary substantially in different socio-economic settings.

Screening recommendations varies across countries, but most guidelines targeted population in the age of 21-65 years, with screening interval of three years

for cytology-based screening or five years for the HPV test/ co-testing. In the US, the 2018 USPSTF recommendations do not prefer one method over another, while the ACS has updated its guideline in 2020 with some major changes including advocating HPV testing every 5 years (because of its higher sensitivity in detecting precancer), and starting age of screening has been increased to 25 years instead of 21 years as in previous guideline.[45] In many settings such as Japan, Hongkong, Taiwan, and Korea, cervical cytology remains the primary screening methods for population-based screening program. The KNCSP provide financial support for all asymptomatic women aged from 20 years to undergo cervical cancer screening by the Pap test (conventional smear or liquid-based cytology) every three years. Combination with HPV test is optional for higher risk individuals or upon personal preference.[47]

Lung cancer screening

Lung cancer screening in high-risk population using LDCT was first endorsed to tackle lung cancer mortality in the US-based National Lung Screening Trial (NLST), by significantly reducing lung cancer mortality by 20.0% and overall mortality by 6.7%, compared with chest radiotherapy screening.[46] Most recently in 2020, the Dutch–Belgian lung-cancer screening trial (Nederlands–Leuvens Longkanker Screenings Onderzoek [NELSON]) echoed the positive effect of low-dose volume CT screening in reducing lung cancer mortality by 24% in men and 33% in women, compared with the unscreened control group.[47] Lung cancer screening by LDCT in high-risk groups, thus can help reduce mortality but also causes false-positive results leading to unneeded tests and invasive procedures,

overdiagnosis, incidental findings, anxiety increase, and, rarely, radiation-induced cancers.[48] However, as LDCTs are performed over a longer period, the benefits of screening is expected to increase.[49]

Lung cancer screening is still being implemented ineffectively. Studies have revealed that despite the release of NLST results and screening recommendations, less than 5% of eligible adults have received screening and the figure remained constant for several years.[50] Meanwhile, improper screening of ineligible subjects appeared to account for a considerable proportion of all screenings done, and follow-up among those who have been screened may be lacking.[51] Slow progress in screening uptake and implementation makes reaching the reduction in lung cancer mortality difficult.

In 2013, the US Preventive Services Task Force (USPSTF) recommended annual LDCT lung cancer screening in people aged 55 to 80 years who currently smoke or have quit within the past 15 years, having at least 30 pack-year smoking history (B recommendation)[52]. Most recently, the USPSTF suggested expanding annual LCS to younger and less intensive smokers, defined as those aged 50 to 80 years with 20 or more pack-years of smoking history who currently smoke or have quit within the past 15 years (B recommendation, moderate certainty of moderate net benefit).[53] This new recommendation was estimated to give greater benefits than the old one by increasing screening eligibility, lung cancer deaths averted, life-year gained, as well as reducing disparity by gender/ethnicity in screening participation.[54] However, these advantages may also come at the expense of elevated harms, such as more false-positive results and overdiagnosed cases,

radiation-related deaths and increased incidental findings. Other recommendations are summarized in table 1.3.

Table 1. 3 Recommendations for lung cancer screening using low-dosed computed tomography (LDCT)

Organization	Main eligible criteria
US Preventive Services Task Force (USPSTF) - 2020	Aged 50 to 80 years who have a 20–pack-year smoking history and currently smoke or have quit within the past 15 years (B recommendation)
Centers for Medicare and Medicaid Services (CMS)	Aged 55 – 77 years who have at least 30–pack-year smoking history and currently smoke or have quit within the past 15 years
American College of Chest Physicians	Aged 55-77 years, 30 pack-years or more and either continue to smoke or have quit within the past 15 years
National Comprehensive Cancer Network	Aged 55 to 77 years who have at least a 30 pack-year smoking history and currently smoke or have quit within the past 15 years
The American Cancer Society	Aged 55-74 years, have at least a 30 pack-year smoking history, and currently smoke or have quit within the past 15 years.
American Association for Thoracic Surgery	Aged 55-79 years with smoking history of at least 30 pack-years
Korea National Cancer Screening Program (KNCSP)	Aged 55-74 years with at least 30 pack-year of smoking history, currently smoke or have quit within the past 15 years.

In South Korea, a previous feasibility pilot study for implementing a national lung cancer screening program was conducted from Feb 2017 to assess 5

predefined feasibility categories: the reliability of recruiting eligible high-risk smoking history population using questionnaires, screening efficiency, screening harms, capability to control the screening quality, and level of current infrastructures to implement a national lung cancer screening program. Reports showed promising results, however several challenges remained affecting the effectiveness of the program including refusal of screening in high-risk group and poor compliance of follow-up diagnostic procedure among individuals with abnormal results.[55]

In 2019, Korea was the first country in the world to introduce nationwide lung cancer screening program, with 90% financial support from The National Health Insurance Service (NHIS) for people aged 55-74 years with at least 30 pack-year of smoking history, currently smoke or have quit within the past 15 years.

1.2.3. Cancer screening operation during the COVID-19 pandemic

The COVID-19 pandemic has significantly hampered nearly every area of cancer control and prevention, including canceled or postponed cancer screening services.[56,57] National cancer screening in most countries has been temporarily halted around March 2020 to control the rapid spread of coronavirus. As a results, compared with the pre-COVID-19 period, screening rates have dropped by 4.1% to 75% for coloscopy screening; 22.2-85% for mammography screening; 57%, 74%, and 56%, for gastroscopies, prostate, and lung screening, respectively, according to a recent systematic review by Ibrahim Alkatout et al.[58]

Since COVID-19 restrictions were adopted, the Netherlands Cancer Registry

has observed a nearly 40% decrease in weekly cancer incidence, while the United Kingdom has seen a 75% reduction in referrals for suspected cancer.[59] In the US, weekly number of newly diagnosed patients dropped 46.4% for 6 types of cancer combined, ranging from 24.7% for pancreatic cancer to 51.8% for breast cancer.[60] Another US study later reported significant reduction in cancer screening, patient visits, surgeries and therapies, especially a sharp fall at the April peak of the pandemic by 85%, 75%, 74%, and 56% in screening rates for breast, colon, prostate, and lung cancer, respectively.[61] Even after full reoperation of previous suspended lung cancer screening program, the monthly number of participants remained low and the proportion of nodules suspicious for cancer (Lung-RADS 4) was significantly increased by 21%.[62]

In Korea, there was a overall 9.9% reduction in the number of breast cancer diagnoses compared with 2019, with the elderly showing the greatest reduction, and a 27.4% decline in breast cancer screening rate.[63] A constant number of lung cancer diagnosis was observed before and after COVID-19 outbreak in a study conducted at three Korean hospitals, most likely due to the country's drastic screening of COVID-19 and proactive triaging of suspected patients, however the proportion of NSCLC patients with advanced stages significantly increased compared with the previous years.[64]

Even after reopening, screening services are still operated at reduced capacities in many settings.[65] Decreased screening attendance, increased non-compliance of screen-positive participants and the huge backlog of individuals needed to be screened post-pandemic are expected to result in tremendous impact,

including increased advanced cancers, mortality rates and years of life lost (YLLs).[66] Though several measures have been implemented during screening procedures to protect patients and staffs, people's hesitance due to COVID-19 concerns appeared to be a major barrier to their compliance of screening recommendations.

In summary, the disruption in cancer screening brought by the COVID-19 pandemic has left a large number of people without access to recommended health care services, which may result in tremendous effect on cancer outcome and survival in the long run. Given current psychosocial threat in the midst of the pandemic, it is still unclear to what extent the fear of COVID-19 exists and how much it is responsible for the decline observed in cancer screening rates. An interesting question is whether people's fear of COVID-19 exceeds that of cancer and actually turns cancer screening into a risk-taking behavior. We conducted this study utilizing a questionnaire survey in a representative sample of the Korean general public, with two specific objectives:

1. To assess the fear of COVID-19 in comparison with that of cancer and lung cancer, as hypothesized that people tended to weigh their fear of having a relevant disease compared with that of coronavirus infection, affecting their decisions to undergo or postpone screening.
2. To examine the association of COVID-19 fear with the behaviors of respondents towards general health check-ups and cancer screening, addressing how much COVID-19 affects population to participate in cancer screening.

2. Methods

2.1. Study design and study population

The Korean National Cancer Screening Survey (KNCSS) was a population-based, cross-sectional survey to investigate cancer screening rates for five major malignancies (gastric, liver, colorectal, breast, and cervix), conducted annually by the National Cancer Center in Korea since 2004. Survey subjects were recruited through a stratified, multistage random sampling procedure based on resident registration population according to geographical area, age, and sex. Details on sampling method was described in the previous studies.[40,67]

Cancer-free men aged from 40 to 74 years and women aged from 20 to 74 years were eligible for participation according to the current protocols issued by the KNCSP.[32] In 2020, data were collected from 05 August to 21 September through face-to-face interview with 43,241 people initially being contacted. After excluding 20,563 people who were absent at the time of household visit and 8,125 non-subjects, the response rate was 30.9% which is 4,500 out of 14,553 subjects. We asked them whether they participated in health check-ups (including cancer screening) as scheduled (figure 2.1). Those aged under 40 years were all women targeted for cervical cancer screening (recommended for women from the age of 20 since 2016). As younger age people tend to have less concern and willingness to engage in health screening,[68] we extracted data on only respondents aged 40 years and above for the final analysis of health check-ups participation to ensure comparable age strata between men and women.

To investigate COVID-19 fear's impact on cancer screening participation among targeted individuals during 2020, we extracted data on eligible screening population for the cancer of stomach, breast, and cervix. According to the KNCSP guidelines, people aged ≥ 40 years are eligible for gastric cancer screening with endoscopy or UGIS, women from the age of 30 are recommended for breast cancer screening with mammography, and women aged ≥ 20 years are eligible for cervical cancer screening with pap smear. Screening interval is 2 years for all these 3 cancers. We did not perform analysis for liver and lung cancer screening as the number of eligible high-risk individuals is relatively small. Also, those underwent colorectal screening could obtain their stool specimen at home and send to the hospital for a test, thus COVID-19 might not have much impact on such home-based screening.

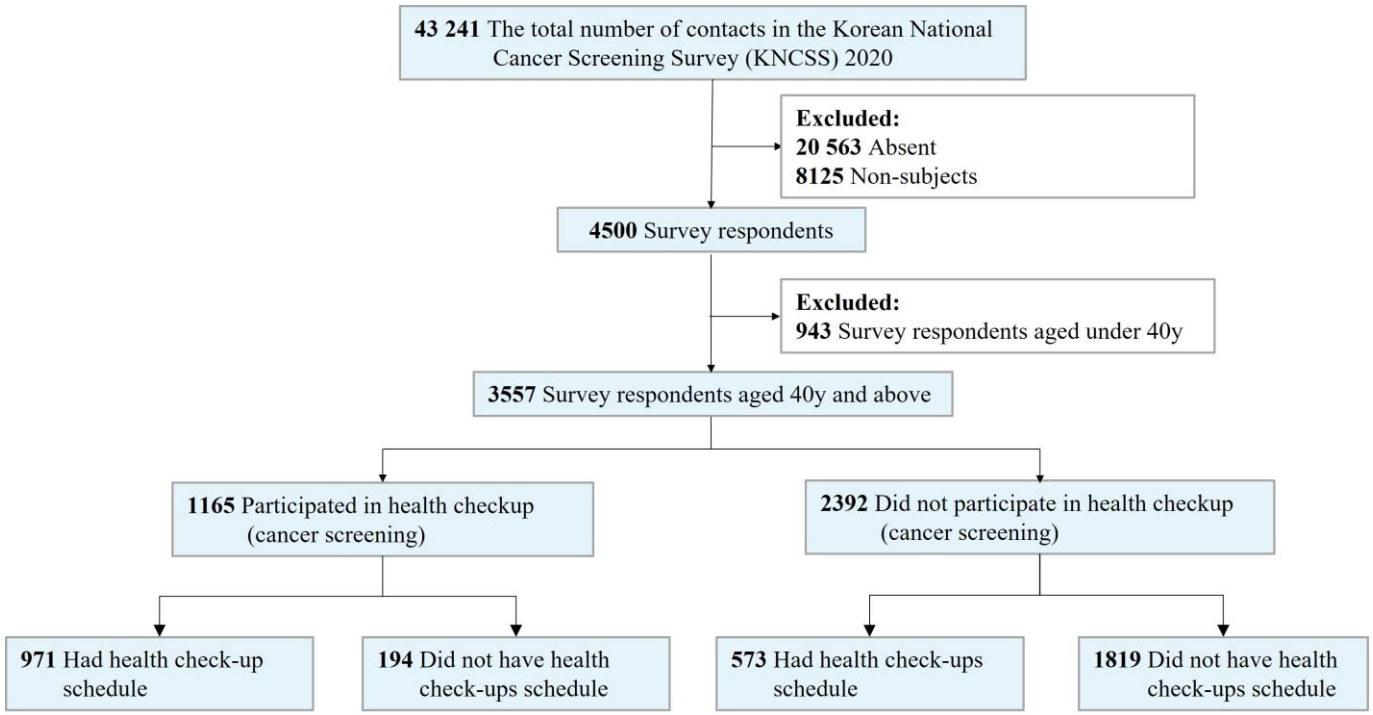

Figure 2. 1 Flow of study participation and groups of participants by having health check-ups with or without schedule

Absent: No one was available at the visiting household.
Non-subjects: Respondents were not subject to the target age group or were acknowledged that they were diagnosed with cancer before the survey interview.

2.2. Measures

Sociodemographic and health-related factors

Information was collected using a structured questionnaire on sociodemographic characteristics (including gender, age, education, household income), residential area (metropolitan city/ urban/ rural) and family history of cancer; health-related status, including comorbidities (having any of the following conditions: hypertension, diabetes, tuberculosis, hepatitis B/C, liver cirrhosis, gastritis, ulcer, colon polyps, benign breast disease, uterine fibroids, hyperlipidemia), smoking status (nonsmoker/ former smoker/ current smoker), and self-perceived general health status (good/ neutral/ bad). Attitudes toward screening was assessed by the question "Do you think cancer screening helps you find and cure cancer at early stage?"; responses were categorized into agree/ disagree.

Impact of COVID-19

We added several specific questions to assess the impact of the COVID-19 pandemic on people's risk perception and health behavior changes, including "Which one is more fearful between coronavirus infection and cancer diagnosis in the current coronavirus spread?" where participants could rate their fear on a five-point scale towards coronavirus or cancer, then their answers were grouped into three main categories: more fear of coronavirus (1-5 points towards coronavirus), neutral (0), or more fear of cancer (1-5 points towards cancer). In addition, we interested in people's perception regarding COVID-19 – an acute respiratory

illness and an urgent health threat, versus lung cancer – a critical malignancy that develops in the respiratory organs of the lungs and also the leading cause of cancer death in South Korea. Thus, we utilized the same method to quantify the fear of COVID-19 compared with lung cancer; the answers then were grouped into three categories: more fear of coronavirus (1-5 points towards coronavirus), neutral (0), or more fear of lung cancer (1-5 points towards lung cancer). Outcome variable regarding health check-ups participation was defined by single question "Did you have any changes in health checkup (including cancer screening) due to COVID-19?"; the answer, which contained four categories: 'participated as scheduled', 'scheduled but did not participate', 'did not schedule but participated', and 'did not schedule and did not participate', was classified into those did and did not participate in cancer screening (with or without schedule) during the pandemic. The reasons for not participating were also investigated by a following multiple-choice question: "Why did you not receive or delay health check-ups (including cancer screening)?". Response options were: In case the medical examination institutions will spread the coronavirus/ Refrain from going out in case of coronavirus infection/ I don't get sick right away, so I want to get it after the pandemic/ Did not receive a call to get health check-ups (no information)/ Not recommended to receive health check-ups near family, workplace, etc./ Having fever or respiratory symptoms/ Due to poor economic conditions such as income decrease/ Others.

Cancer screening experience

All participants were asked about their previous screening experience and the most recent screening activities for each screening modality of each cancer (within one year/ within 2 years/ more than 2 years). For breast cancer screening, both mammography and ultrasound screening were included in our final analysis as ultrasound was often used as follow-up test or alternative to mammography in KNCSP with additional payment. Similarly, we included screening by either pap smear or HPV DNA test for cervical cancer since women are allowed to freely choose between the two modalities but must pay additional cost for HPV test. Those answered to be screened in the last one year were considered to have participated in screening during the pandemic. For the three-cancer screening under our interest (stomach, breast, and cervix), we excluded those answered that they had been screened during the previous two years since we assume that these people no longer had to participate in screening during 2020.

To tackle the high mortality rate of lung cancer, Korea lung cancer screening program was provided to high-risk groups composed of current and ex-smokers who have quit smoking within 15 years, aged 55 to 74 years with 30 pack-years or more of smoking history. Unfortunately, we could not obtain information regarding their participation in lung cancer screening from the KNCSS 2020. Instead, we attempted to assess the fear perception of COVID-19 compared with lung cancer in this high-risk group as well as their engagement in health screening during the pandemic. Data on smoking duration, intensity and past quit attempt were collected and analyzed for exploratory analysis on eligible lung cancer screening

participants.

2.3. Statistical analysis

We performed descriptive analysis to explore study participants' characteristics, including gender, age, education, household income, residential area, family history of cancer, self-perceived general health status, comorbidities, smoking status, attitudes toward screening and the fear of COVID-19 compared with cancer/ lung cancer. Frequencies with percentages were calculated for each categorical variables and a Chi-square test was used to determine a significant difference between two categorical variables. Spearman rank test was used to examine the monotonic change in health check-ups non-participation across levels of Coronavirus fear in comparison with cancer/ lung cancer.

Univariable and multivariable logistic regression models (including all variables listed above) were applied to identify factors associated with health check-ups and cancer screening participation.

Sensitivity analysis was performed to assess the COVID-19 fear's impact on screening participation in only those with pre-scheduled health check-ups and in each age group (age stratification). Also, to evaluate the consistency of findings, we re-categorized the fear of COVID-19 compared with cancer/ lung cancer into 3 groups: more fear of coronavirus (2-5 points towards coronavirus), neutral (0 and 1 point towards either coronavirus or cancer/ lung cancer), and more fear of cancer/ lung cancer (2-5 points towards cancer/ lung cancer). In addition, we also subdivided the fear into 5 groups to further explore the dose-response relationship

between the COVID-19 fear and screening uptake during the pandemic (4-5 points towards coronavirus/ 1-3 points towards coronavirus/ 0 – neutral/ 1-3 points towards cancer/ 4-5 points towards cancer).

All statistical analysis were done by using STATA software version 16 (Stata Corp. L.P., College Station, TX). All p values were calculated from two-sided tests with significant level of 5%.

2.4. Ethics

The subjects consented to participate in the survey for public purposes; the requirement for written informed consent was waived.

3. Results

3.1. Characteristics of study participants

3.1.1. Health-checkups participation

Among 3557 respondents aged ≥ 40 years in KNCSS 2020 (table 3.1), 2392 (67.25%) did not participate in health check-ups including cancer screening during the COVID-19 pandemic, of which 573 (24.0%) had a schedule for health check-ups but did not receive. The majority of respondents were high school graduates (53.81%), had household income level ≥ 4 000 000 KRW (54.88%), living in metropolitan cities or urban areas (90.58%), and having good self-perceived health status (64.69%).

1197 (33.65%) people were more fearful of coronavirus than cancer, and 1066 (29.97%) people perceived more fear of COVID-19 than lung cancer. 33.92% of those perceived more fear of lung cancer have participated in medical check-ups during the pandemic, whereas only 30.11% of those with more fear of COVID-19 have participated.

Table 3. 1 Characteristics of survey respondents (N = 3557)

	Participated as scheduled	**Scheduled but did not participate**	**Did not schedule but participated**	**Did not schedule and did not participate**	**Total**	**P-value**
Total, n (%)	971 (27.30)	573 (16.11)	194 (5.45)	1819 (51.14)	3557 (100.00)	
Gender, n (%)						
Male	461 (47.48)	301 (52.53)	97 (50.00)	898 (49.37)	1757 (49.40)	
Female	510 (52.52)	272 (47.47)	97 (50.00)	921 (50.63)	1800 (50.60)	0.29
Age group, n (%)						
40-49	290 (29.87)	176 (30.72)	52 (26.80)	572 (31.45)	1090 (30.64)	
50-59	326 (33.57)	174 (30.37)	64 (32.99)	567 (31.17)	1131 (31.80)	
60-74	355 (36.56)	223 (38.92)	78 (40.21)	680 (37.38)	1336 (37.56)	0.67
Household income level, n (%)						
Below 2,000,000 KRW	89 (9.17)	52 (9.08)	23 (11.86)	191 (10.50)	355 (9.98)	
2,000,000-3,990,000 KRW	296 (30.48)	191 (33.33)	98 (50.52)	665 (36.56)	1250 (35.14)	
4,000,000 KRW and above	586 (60.35)	330 (57.59)	73 (37.63)	963 (52.94)	1952 (54.88)	<0.001
Education level, n (%)						
Middle school or below	117 (12.05)	65 (11.34)	43 (22.16)	298 (16.38)	523 (14.70)	
High school	508 (52.32)	320 (55.85)	108 (55.67)	978 (53.77)	1914 (53.81)	
Undergraduate and above	346 (35.63)	188 (32.81)	43 (22.16)	543 (29.85)	1120 (31.49)	<0.001
Residential area, n (%)						
Metropolitan city	457 (47.06)	282 (49.21)	83 (42.78)	792 (43.54)	1614 (45.38)	
Urban	440 (45.31)	262 (45.72)	99 (51.03)	807 (44.37)	1608 (45.21)	
Rural	74 (7.62)	29 (5.06)	12 (6.19)	220 (12.09)	335 (9.42)	<0.001
Family history of cancer, n (%)						
No	818 (84.24)	480 (83.77)	171 (88.14)	1553 (85.38)	3022 (84.96)	
Yes	153 (15.76)	93 (16.23)	23 (11.86)	266 (14.62)	535 (15.04)	0.42
Cancer screening helps detect early and cure cancer? n (%)						
Agree	923 (95.06)	538 (93.89)	172 (88.66)	1682 (92.47)	3315 (93.20)	
Disagree	48 (4.94)	35 (6.11)	22 (11.34)	137 (7.53)	242 (6.80)	0.004
Self-perceived general health status, n (%)						
Good	612 (63.03)	328 (57.24)	127 (65.46)	1234 (67.84)	2301 (64.69)	
Neutral	320 (32.96)	224 (39.09)	63 (32.47)	519 (28.53)	1126 (31.66)	
Bad	39 (4.02)	21 (3.66)	4 (2.06)	66 (3.63)	130 (3.65)	<0.001
Comorbidities*, n (%)						
No	547 (56.33)	281 (49.04)	119 (61.34)	1053 (57.89)	2000 (56.23)	
Yes	424 (43.67)	292 (50.96)	75 (38.66)	766 (42.11)	1557 (43.77)	0.001
Smoking status, n (%)						
Nonsmoker	647 (66.63)	362 (63.18)	129 (66.49)	1171 (64.38)	2309 (64.91)	
Former smoker	242 (24.92)	150 (26.18)	52 (26.80)	458 (25.18)	902 (25.36)	
Current smoker	82 (8.44)	61 (10.65)	13 (6.70)	190 (10.45)	346 (9.73)	0.40
More fear of Coronavirus or cancer, n (%)						
More fear of cancer	521 (53.66)	296 (51.66)	114 (58.76)	976 (53.66)	1197 (33.65)	
Neutral	133 (13.70)	59 (10.30)	20 (10.31)	241 (13.25)	453 (12.74)	
More fear of Coronavirus	317 (32.65)	218 (38.05)	60 (30.93)	602 (33.10)	1907 (53.61)	0.12
More fear of Coronavirus or lung cancer, n (%)						
More fear of lung cancer	574 (59.11)	308 (53.75)	116 (59.79)	1036 (56.95)	1066 (29.97)	
Neutral	127 (13.08)	62 (10.82)	27 (13.92)	241 (13.25)	457 (12.85)	
More fear of Coronavirus	270 (27.81)	203 (35.43)	51 (26.29)	542 (29.80)	2034 (57.18)	0.05

**Comorbidities included either of the following conditions: hypertension, diabetes, tuberculosis, hepatitis B/C, liver cirrhosis, gastritis, ulcer, colon polyps, benign breast disease, uterine fibroids, hyperlipidemia*

3.1.2. Gastric cancer screening participation

A total of 2077 respondents were included in the analysis for gastric cancer screening participation during the COVID-19 pandemic (after excluding 1480 adults that had been screened during 2019) (table 3.2). Among them, 1110 (53.44%) did not attend screening for gastric cancer in 2020. Most respondents were high school graduates (51.85%) and had household income level ≥ 4 000 000 KRW (52.86%). There were some significant differences in characteristics of respondents who did and did not participate in gastric cancer screening during the pandemic, including household income, residential area, cancer family history, perceived cancer screening benefit, perceived health status, comorbidities, and fear of COVID-19 vs. cancer.

720 people (34.67%) perceived more fear of COVID-19 over cancer, of which 56.94% did not undergo gastric cancer screening in 2020, while this figure was 50.55% among those perceived more fear of cancer.

Table 3. 2 Characteristics of eligible population for gastric cancer screening

	Non-Participants	Participants**	Total	P-value
Total, n (%)	1110 (53.44)	967 (46.56)	2077 (100.00)	
Gender, n (%)				
Male	544 (49.01)	469 (48.50)	1013 (48.77)	
Female	566 (50.99)	498 (51.50)	1064 (51.23)	0.82
Age group, n (%)				
40-49	372 (33.51)	290 (29.99)	662 (31.87)	
50-59	325 (29.28)	320 (33.09)	645 (31.05)	
60-74	413 (37.21)	357 (36.92)	770 (37.07)	0.11
Household income level, n (%)				
Below 2,000,000 KRW	156 (14.05)	97 (10.03)	253 (12.18)	
2,000,000-3,990,000 KRW	396 (35.68)	330 (34.13)	726 (34.95)	
4,000,000 KRW and above	558 (50.27)	540 (55.84)	1098 (52.86)	0.01
Education level, n (%)				
Middle school or below	198 (17.84)	137 (14.17)	335 (16.13)	
High school	564 (50.81)	513 (53.05)	1077 (51.85)	
Undergraduate and above	348 (31.35)	317 (32.78)	665 (32.02)	0.08
Residential area, n (%)				
Metropolitan city	517 (46.58)	378 (39.09)	895 (43.09)	
Urban	491 (44.23)	488 (50.47)	979 (47.14)	
Rural	102 (9.19)	101 (10.44)	203 (9.77)	0.003
Family history of cancer, n (%)				
No	966 (87.03)	792 (81.90)	1758 (84.64)	
Yes	144 (12.97)	175 (18.10)	319 (15.36)	0.001
Cancer screening helps detect early and cure cancer?, n (%)				
Agree	1002 (90.27)	911 (94.21)	1913 (92.10)	
Disagree	108 (9.73)	56 (5.79)	164 (7.90)	0.001
Self-perceived general health status, n (%)				
Good	682 (61.44)	651 (67.32)	1333 (64.18)	
Neutral	388 (34.95)	276 (28.54)	664 (31.97)	
Bad	40 (3.60)	40 (4.14)	80 (3.85)	0.01
Comorbidities*, n (%)				
No	689 (62.07)	514 (53.15)	1203 (57.92)	
Yes	421 (37.93)	453 (46.85)	874 (42.08)	<0.001
Smoking status, n (%)				
Nonsmoker	735 (66.22)	636 (65.77)	1371 (66.01)	
Former smoker	291 (26.22)	233 (24.10)	524 (25.23)	
Current smoker	84 (7.57)	98 (10.13)	182 (8.76)	0.09
More fear of Coronavirus or cancer, n (%)				
More fear of cancer	547 (49.28)	535 (55.33)	720 (34.67)	
Neutral	153 (13.78)	122 (12.62)	275 (13.24)	
More fear of Coronavirus	410 (36.94)	310 (32.06)	1082 (52.09)	0.02

**Comorbidities included either of the following conditions: hypertension, diabetes, tuberculosis, hepatitis B/C, liver cirrhosis, gastritis, ulcer, colon polyps, benign breast disease, uterine fibroids, hyperlipidemia*

***Participants in gastric cancer screening during the pandemic*

3.1.3. Breast cancer screening participation

1041 women aged ≥ 40 years were finally included in the analysis for breast cancer screening participation during the COVID-19 pandemic (after excluding 759 women that had been screened during 2019) (table 3.3). Among them, 567 (54.47%) did not attend screening in 2020. Most respondents were high school graduates (55.91%) and had household income level ≥ 4 000 000 KRW (54.27%). Women who did and did not participate in breast cancer screening during the pandemic differed significantly in age, household income, education level, residential area, perceived cancer screening benefit, perceived health status and comorbidities.

Table 3. 3 Characteristics of eligible population for breast cancer screening

	Non-Participants	Participants**	Total	P-value
Total, n (%)	567 (54.47)	474 (45.53)	1041 (100.00)	
Age group, n (%)				
40-49	164 (28.92)	145 (30.59)	309 (29.68)	
50-59	160 (28.22)	166 (35.02)	326 (31.32)	
60-74	243 (42.86)	163 (34.39)	406 (39.00)	0.01
Household income level, n (%)				
Below 2,000,000 KRW	106 (18.69)	45 (9.49)	151 (14.51)	
2,000,000-3,990,000 KRW	179 (31.57)	146 (30.80)	325 (31.22)	
4,000,000 KRW and above	282 (49.74)	283 (59.70)	565 (54.27)	<0.001
Education level, n (%)				
Middle school or below	137 (24.16)	66 (13.92)	203 (19.50)	
High school	307 (54.14)	275 (58.02)	582 (55.91)	
Undergraduate and above	123 (21.69)	133 (28.06)	256 (24.59)	<0.001
Residential area, n (%)				
Metropolitan city	272 (47.97)	186 (39.24)	458 (44.00)	
Urban	235 (41.45)	247 (52.11)	482 (46.30)	
Rural	60 (10.58)	41 (8.65)	101 (9.70)	0.003
Family history of cancer, n (%)				
No	491 (86.60)	398 (83.97)	889 (85.40)	
Yes	76 (13.40)	76 (16.03)	152 (14.60)	0.23
Cancer screening helps detect early and cure cancer?, n (%)				
Agree	502 (88.54)	454 (95.78)	956 (91.83)	
Disagree	65 (11.46)	20 (4.22)	85 (8.17)	<0.001
Self-perceived general health status, n (%)				
Good	318 (56.08)	301 (63.50)	619 (59.46)	
Neutral	213 (37.57)	158 (33.33)	371 (35.64)	
Bad	36 (6.35)	15 (3.16)	51 (4.90)	0.01
Comorbidities*, n (%)				
No	325 (57.32)	242 (51.05)	567 (54.47)	
Yes	242 (42.68)	232 (48.95)	474 (45.53)	0.04
Smoking status, n (%)				
Nonsmoker	549 (96.83)	460 (97.05)	1009 (96.93)	
Former smoker	10 (1.76)	9 (1.90)	19 (1.83)	
Current smoker	8 (1.41)	5 (1.05)	13 (1.25)	0.87
More fear of Coronavirus or cancer, n (%)				
More fear of cancer	282 (49.74)	250 (52.74)	381 (36.60)	
Neutral	72 (12.70)	56 (11.81)	128 (12.30)	
More fear of Coronavirus	213 (37.57)	168 (35.44)	532 (51.10)	0.63

**Comorbidities included either of the following conditions: hypertension, diabetes, tuberculosis, hepatitis B/C, liver cirrhosis, gastritis, ulcer, colon polyps, benign breast disease, uterine fibroids, hyperlipidemia*

***Participants in breast cancer screening (mammography/ breast ultrasound) during the pandemic*

3.1.4. Cervical cancer screening participation

Total 1888 women aged ≥ 20 years were included in the analysis for cervical cancer screening participation during the COVID-19 pandemic (after excluding 855 women that had been screened during 2019) (table 3.4). Among them, 1289 (68.27%) did not attend screening in 2020. Most respondents were under 40 years of age (40.04%), had high school education level or above, and had household income level ≥ 4 000 000 KRW (59.0%). Women who did and did not undergo cervical cancer screening during the pandemic differed significantly in all variables evaluated, except for smoking status and the fear of COVID-19 versus cancer. 679 women (35.96%) perceived more fear of COVID-19 over cancer, of which 71.93% did not undergo cervical cancer screening in 2020, while this figure was 67.35% among those perceived more fear of cancer.

Table 3. 4 Characteristics of eligible population for cervical cancer screening

	Non-Participants	Participants**	Total	P-value
Total, n (%)	1289 (68.27)	599 (31.73)	1888 (100.00)	
Age group, n (%)				
Under 40	569 (44.14)	187 (31.22)	756 (40.04)	
40-49	195 (15.13)	135 (22.54)	330 (17.48)	
50-59	198 (15.36)	142 (23.71)	340 (18.01)	
60-74	327 (25.37)	135 (22.54)	462 (24.47)	<0.001
Household income level, n (%)				
Below 2,000,000 KRW	146 (11.33)	39 (6.51)	185 (9.80)	
2,000,000-3,990,000 KRW	405 (31.42)	184 (30.72)	589 (31.20)	
4,000,000 KRW and above	738 (57.25)	376 (62.77)	1114 (59.00)	0.003
Education level, n (%)				
Middle school or below	177 (13.73)	57 (9.52)	234 (12.39)	
High school	537 (41.66)	287 (47.91)	824 (43.64)	
Undergraduate and above	575 (44.61)	255 (42.57)	830 (43.96)	0.01
Residential area, n (%)				
Metropolitan city	600 (46.55)	243 (40.57)	843 (44.65)	
Urban	573 (44.45)	317 (52.92)	890 (47.14)	
Rural	116 (9.00)	39 (6.51)	155 (8.21)	0.002
Family history of cancer, n (%)				
No	1151 (89.29)	516 (86.14)	1667 (88.29)	
Yes	138 (10.71)	83 (13.86)	221 (11.71)	0.048
Cancer screening helps detect early and cure cancer?, n (%)				
Agree	1170 (90.77)	571 (95.33)	1741 (92.21)	
Disagree	119 (9.23)	28 (4.67)	147 (7.79)	0.001
Self-perceived general health status, n (%)				
Good	898 (69.67)	420 (70.12)	1318 (69.81)	
Neutral	339 (26.30)	170 (28.38)	509 (26.96)	
Bad	52 (4.03)	9 (1.50)	61 (3.23)	0.01
Comorbidities*, n (%)				
No	932 (72.30)	396 (66.11)	1328 (70.34)	
Yes	357 (27.70)	203 (33.89)	560 (29.66)	0.01
Smoking status, n (%)				
Nonsmoker	1239 (96.12)	580 (96.83)	1819 (96.35)	
Former smoker	35 (2.72)	12 (2.00)	47 (2.49)	
Current smoker	15 (1.16)	7 (1.17)	22 (1.17)	0.65
More fear of Coronavirus or cancer, n (%)				
More fear of cancer	649 (50.35)	333 (55.59)	679 (35.96)	
Neutral	157 (12.18)	70 (11.69)	227 (12.02)	
More fear of Coronavirus	483 (37.47)	196 (32.72)	982 (52.01)	0.09

**Comorbidities included either of the following conditions: hypertension, diabetes, tuberculosis, hepatitis B/C, liver cirrhosis, gastritis, ulcer, colon polyps, benign breast disease, uterine fibroids, hyperlipidemia*

***Participants in cervical cancer screening (pap smear/ HPV DNA test) during the pandemic*

3.2. Trends in health screening participation according to the fear of COVID-19

3.2.1. Fear of COVID-19 compared with cancers/ lung cancer in the general population

Figure 3.1 shows in detail the distribution of the fear of COVID-19 compared with cancers/ lung cancer in our general population aged ≥ 40 years. 1197 (33.65%) people were more fearful of coronavirus than cancer, while 453 (12.74%) perceived equal fear of the two diseases and 1907 (53.61%) were more fearful of cancer. Additionally, 1066 (29.97%) people perceived more fear of COVID-19 than lung cancer, while 457 (12.85%) perceived equal fear of the two diseases and 2034 (57.18%) were more fearful of lung cancer.

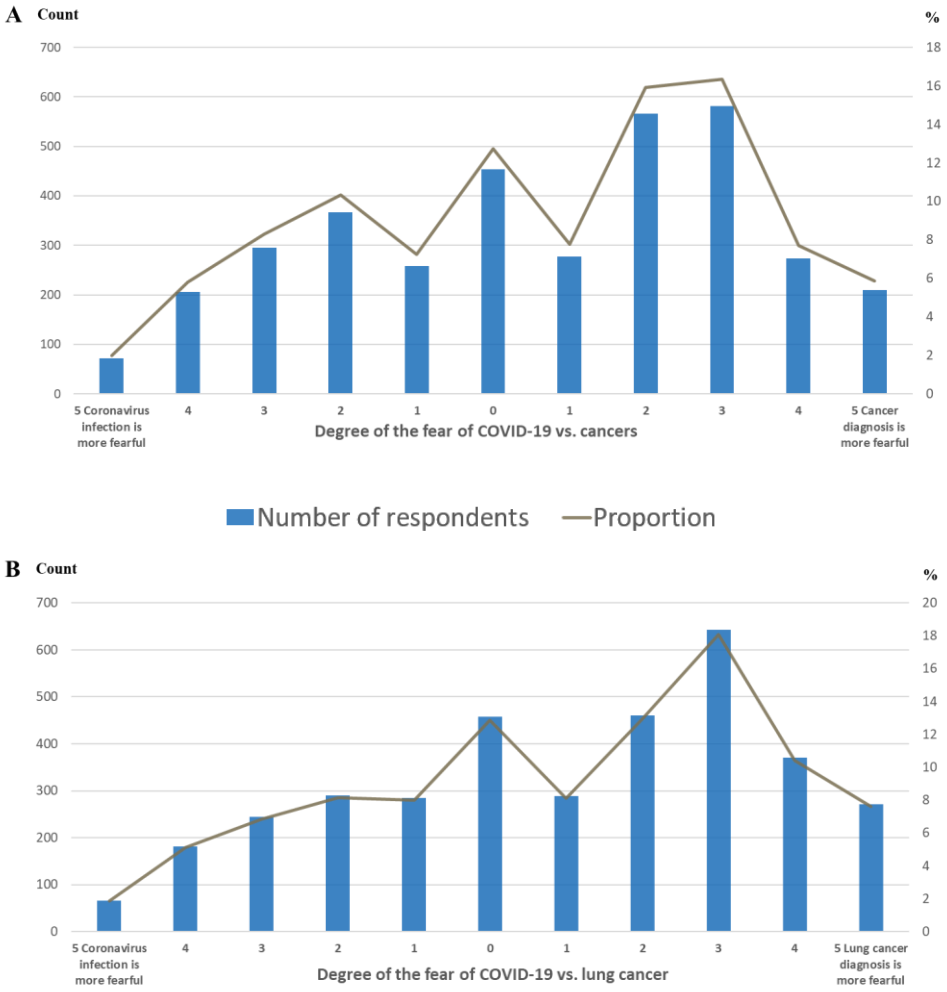

Figure 3. 1 Fear of COVID-19 compared with cancers/ lung cancer in the general population

(A) Fear of COVID-19 versus cancers

(B) Fear of COVID-19 versus lung cancer

3.2.2. Trends by the fear of COVID-19 versus cancer

Figure 3.2 plots the number of respondents and percentage of those did not participate in health check-ups across 11 levels of the fear of COVID-19 in comparison with cancer, thus revealing the trend in health check-ups non-participation when the fear of COVID-19 increases and exceeds that of cancer. We could not see the trend in non-participation rate overall (A) (Spearman correlation coefficient rho = -0.08; p = 0.81), however we observed a statistically significant increase (rho = -0.73; p = 0.01) in the percentage of those had check-ups schedule but did not participate (B) when the fear of lung COVID-19 increases and exceeds that of cancer.

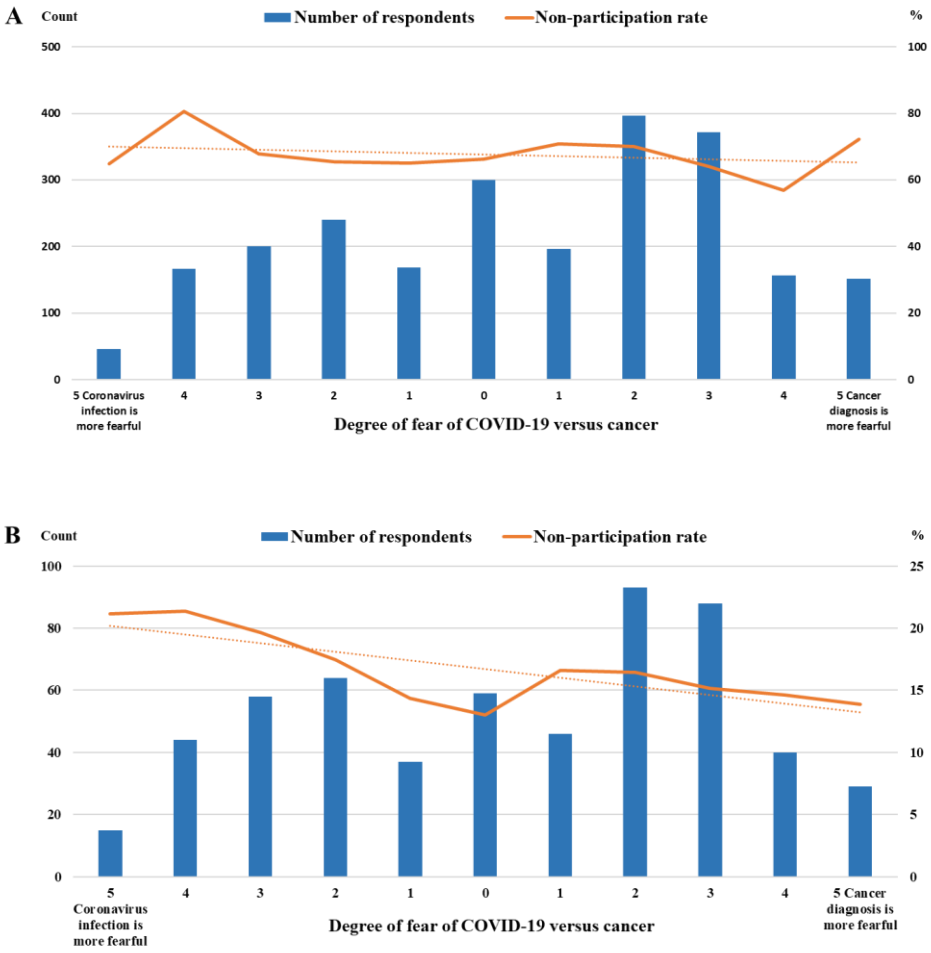

Figure 3. 2 Trends in health check-ups non-participation by the fear of COVID-19 versus cancer

(A) Total non-participation in health check-ups

(B) Scheduled but did not participate

3.2.3. Trend by the fear of COVID-19 versus lung cancer

Similarly, figure 3.3 reveals the trend in health check-ups non-participation when the fear of COVID-19 increases and exceeds that of lung cancer. The pattern in the rates of non-participation overall (A) was not apparent (rho = -0.45; p = 0.17), however we observed a statistically significant increase (rho = -0.75; p = 0.0073) in the percentage of those had check-ups schedule but did not participate (B) when the fear of lung COVID-19 increases and exceeds that of lung cancer.

Figure 3. 3 Trends in health check-ups non-participation by the fear of COVID-19 versus lung cancer

(A) Total non-participation in health check-ups

(B) Scheduled but did not participate

3.2.4. Screening participation by age group and the fear of COVID-19

Table 3.5 shows screening participation rates by age group and fear of COVID-19 versus cancer. Participation rates are the lowest among younger ages (20-49 years old) with more fear of COVID-19. For instance, only 28-29% of those aged 40-49 years who perceived more fear of COVID-19 had participated in health check-ups during the pandemic, whereas the rates increased up to more than 35% in other age groups. With cervical cancer screening, only 19.7% and 16.3% of those aged < 40 years with more or equal fear of COVID-19 compared with cancer - had undergone screening during the pandemic, which were much lower than the average rate (31.73%). Meanwhile, the rate in those at the same age but perceived more fear of cancer was about 30%. Similar trends were also observed in gastric and breast cancer screening.

Table 3. 5 Screening participation by age group and the fear of COVID-19

	Age group	Fear of COVID-19 versus cancer						All		Chi-square test
		More fear of COVID-19		Neutral		More fear of cancer				
		N	Participation rate	N	Participation rate	N	Participation rate	N	Participation rate	
Health check-ups participation	40-49 years	349	28.65%	138	28.99%	603	33.50%	1090	31.38%	
	50-59 years	379	35.62%	151	36.42%	601	33.28%	1131	34.48%	
	60-74 years	469	30.28%	164	35.37%	703	33.14%	1336	32.41%	
	All	1197	31.50%	453	33.77%	1907	33.30%	3557	32.75%	0.42
Gastric cancer screening participation	40-49 years	349	38.07%	138	36.26%	603	49.29%	1090	43.81%	
	50-59 years	379	46.64%	151	49.40%	601	51.62%	1131	49.61%	
	60-74 years	469	44.09%	164	47.52%	703	47.69%	1336	46.36%	
	All	1197	43.06%	453	44.36%	1907	49.45%	3557	46.56%	0.02
Breast cancer screening participation	40-49 years	349	37.50%	138	38.46%	603	54.82%	1090	46.93%	
	50-59 years	379	54.40%	151	55.26%	601	47.24%	1131	50.92%	
	60-74 years	469	40.13%	164	39.22%	703	40.39%	1336	40.15%	
	All	1197	44.09%	453	43.75%	1907	46.99%	3557	45.53%	0.04
Cervical cancer screening participation	< 40 years	313	19.69%	108	16.30%	522	29.88%	943	24.74%	
	40-49 years	349	32.74%	138	41.46%	603	46.02%	1090	40.91%	
	50-59 years	379	44.78%	151	45.24%	601	38.41%	1131	41.76%	
	60-74 years	469	27.75%	164	36.54%	703	28.69%	1336	29.22%	
	All	1510	28.87%	561	30.84%	2429	33.91%	4500	31.73%	<0.001

3.3. Factors associated with health check-ups and cancer screening participation during the COVID-19 pandemic

3.3.1. Health check-ups participation

Variables associated with participation in health check-ups are presented in table 3.6. Older aged people were more likely to participate compared with those aged 40-49 years. On the other hand, living in rural area or currently smoking lowered the odds of check-ups attendance. Regarding our main interest, excess fear of COVID-19 over cancer did not show significant effect on health check-ups participation, however respondents with more fear of Coronavirus compared with lung cancer showed decreased likelihood of attendance in health check-ups in both univariable (OR, 0.84; 95% CI, 0.72-0.98) and multivariable models (OR, 0.82; 95% CI, 0.70-0.96).

Table 3. 6 Factors associated with health check-ups participation during the pandemic

	Univariable		Multivariable[ψ]		Multivariable[¥]	
	OR (95% CI)	**p value**	**aOR (95% CI)**	**p value**	**aOR (95% CI)**	**p value**
Gender						
Male	1 (ref)		1 (ref)		1 (ref)	
Female	1.09 (0.95-1.26)	0.21	1.07 (0.88-1.31)	0.49	0.11 (0.87-1.3)	0.54
Age group						
40-49	1 (ref)		1 (ref)		1 (ref)	
50-59	1.15 (0.96-1.37)	0.12	**1.25 (1.04-1.51)**	**0.02**	**1.25 (1.04-1.51)**	**0.02**
60-74	1.05 (0.88-1.25)	0.59	**1.29 (1.03-1.61)**	**0.03**	**1.28 (1.03-1.61)**	**0.03**
Household income level						
Below 2,000,000 KRW	1 (ref)		1 (ref)		1 (ref)	
2,000,000-3,990,000 KRW	1 (0.77-1.29)	0.99	0.97 (0.73-1.29)	0.82	0.97 (0.73-1.29)	0.81
4,000,000 KRW and above	1.11 (0.87-1.41)	0.42	1.02 (0.75-1.38)	0.91	1.02 (0.75-1.38)	0.91
Education level						
Middle school or below	1 (ref)		1 (ref)		1 (ref)	
High school	1.08 (0.87-1.33)	0.49	1.09 (0.85-1.4)	0.5	1.09 (0.84-1.4)	0.52
Undergraduate and above	1.21 (0.97-1.51)	0.1	1.34 (0.99-1.81)	0.06	1.32 (0.98-1.79)	0.07
Residential area						
Metropolitan city	1 (ref)		1 (ref)		1 (ref)	
Urban	1 (0.87-1.16)	0.97	1.02 (0.88-1.19)	0.77	1.03 (0.89-1.19)	0.7
Rural	**0.69 (0.53-0.9)**	**0.01**	**0.71 (0.54-0.93)**	**0.01**	**0.7 (0.53-0.92)**	**0.01**
Family history of cancer						
No	1 (ref)		1 (ref)		1 (ref)	
Yes	1.01 (0.83-1.23)	0.94	0.99 (0.81-1.21)	0.93	0.99 (0.82-1.21)	0.96
Cancer screening helps detect early and cure cancer?						
Agree	1 (ref)		1 (ref)		1 (ref)	
Disagree	0.83 (0.62-1.1)	0.19	0.8 (0.6-1.07)	0.13	0.81 (0.61-1.09)	0.16
Self-perceived general health status						
Good	1 (ref)		1 (ref)		1 (ref)	
Neutral	1.09 (0.94-1.27)	0.27	1.13 (0.96-1.33)	0.13	1.14 (0.97-1.33)	0.12
Bad	1.04 (0.72-1.52)	0.82	1.11 (0.75-1.66)	0.59	1.11 (0.75-1.65)	0.61
Comorbidities*						
No	1 (ref)		1 (ref)		1 (ref)	
Yes	0.94 (0.82-1.09)	0.43	0.89 (0.76-1.04)	0.15	0.89 (0.76-1.05)	0.16
Smoking status						
Nonsmoker	1 (ref)		1 (ref)		1 (ref)	
Former smoker	0.96 (0.81-1.13)	0.58	0.99 (0.79-1.23)	0.92	0.98 (0.78-1.22)	0.84
Current smoker	**0.75 (0.58-0.96)**	**0.02**	0.76 (0.57-1.01)	0.06	**0.75 (0.56-1)**	**0.047**
More fear of Coronavirus or cancer						
More fear of cancer	1 (ref)		1 (ref)			
Neutral	1.02 (0.82-1.27)	0.85	1 (0.81-1.25)	0.98		
More fear of Coronavirus	0.92 (0.79-1.08)	0.3	0.9 (0.77-1.05)	0.19		
More fear of Coronavirus or lung cancer						
More fear of lung cancer	1 (ref)		1 (ref)		1 (ref)	
Neutral	0.99 (0.8-1.23)	0.93			0.96 (0.77-1.19)	0.71
More fear of Coronavirus	**0.84 (0.72-0.98)**	**0.03**			**0.82 (0.7-0.96)**	**0.02**

OR = Odds ratio; aOR = adjusted odds ratio; CI = Confidence interval

**Comorbidities included either of the following conditions: hypertension, diabetes, tuberculosis, hepatitis B/C, liver cirrhosis, gastritis, ulcer, colon polyps, benign breast disease, uterine fibroids, hyperlipidemia*

[ψ] Adjusted for all other variables in the table (except the fear of Coronavirus compared with lung cancer)

[¥] Adjusted for all other variables in the table (except the fear of Coronavirus compared with cancer)

3.3.2. Gastric cancer screening

Table 3.7 shows results for the variables associated with gastric cancer screening participation during 2020. People with higher household income, living in urban/ rural areas, having family history of cancer or having comorbidities were more likely to have undergone screening in the multivariable model. Those who disagreed that cancer screening can help detect early and cure cancer, were less likely to participate in screening (OR, 0.65; 95% CI, 0.46-0.92). The excess fear of COVID-19 over cancer significantly hampered participation in gastric cancer screening in both univariable (OR, 0.77; 95% CI, 0.64-0.93) and multivariable model (OR, 0.81; 95% CI, 0.66-0.98).

Table 3. 7 Factors associated with gastric cancer screening during the pandemic

	Univariable		Multivariable[ψ]	
	OR (95% CI)	**p value**	**aOR (95% CI)**	**p value**
Gender				
Male	1 (ref)		1 (ref)	
Female	1.02 (0.86-1.21)	0.82	1.05 (0.82-1.35)	0.69
Age group				
40-49	1 (ref)		1 (ref)	
50-59	**1.26 (1.02-1.57)**	**0.04**	1.24 (0.98-1.56)	0.08
60-74	1.11 (0.9-1.37)	0.33	1.23 (0.93-1.63)	0.15
Household income level				
Below 2,000,000 KRW	1 (ref)		1 (ref)	
2,000,000-3,990,000 KRW	**1.34 (1-1.8)**	**0.05**	1.4 (0.99-1.96)	0.05
4,000,000 KRW and above	**1.56 (1.18-2.06)**	**0.002**	**1.57 (1.09-2.25)**	**0.02**
Education level				
Middle school or below	1 (ref)		1 (ref)	
High school	**1.31 (1.03-1.69)**	**0.03**	1.21 (0.88-1.65)	0.24
Undergraduate and above	**1.32 (1.01-1.72)**	**0.04**	1.3 (0.89-1.89)	0.18
Residential area				
Metropolitan city	1 (ref)		1 (ref)	
Urban	**1.36 (1.13-1.63)**	**0.001**	**1.43 (1.18-1.72)**	**<0.001**
Rural	**1.35 (1-1.84)**	**0.05**	**1.58 (1.15-2.19)**	**0.01**
Family history of cancer				
No	1 (ref)		1 (ref)	
Yes	**1.48 (1.17-1.88)**	**0.001**	**1.37 (1.07-1.76)**	**0.01**
Cancer screening helps detect early and cure cancer?				
Agree	1 (ref)		1 (ref)	
Disagree	**0.57 (0.41-0.8)**	**0.001**	**0.65 (0.46-0.92)**	**0.01**
Self-perceived general health status				
Good	1 (ref)		1 (ref)	
Neutral	**0.75 (0.62-0.9)**	**0.002**	**0.7 (0.57-0.86)**	**0.001**
Bad	1.05 (0.67-1.65)	0.84	0.93 (0.57-1.52)	0.78
Comorbidities*				
No	1 (ref)		1 (ref)	
Yes	**1.44 (1.21-1.72)**	**<0.001**	**1.52 (1.25-1.87)**	**<0.001**
Smoking status				
Nonsmoker	1 (ref)		1 (ref)	
Former smoker	0.93 (0.76-1.13)	0.45	0.9 (0.68-1.18)	0.43
Current smoker	1.35 (0.99-1.84)	0.06	1.24 (0.86-1.78)	0.24
More fear of Coronavirus or cancer				
More fear of cancer	1 (ref)		1 (ref)	
Neutral	0.82 (0.62-1.06)	0.13	0.84 (0.64-1.11)	0.22
More fear of Coronavirus	**0.77 (0.64-0.93)**	**0.01**	**0.81 (0.66-0.98)**	**0.03**

OR = Odds ratio; aOR = adjusted odds ratio; CI = Confidence interval

** Comorbidities included either of the following conditions: hypertension, diabetes, tuberculosis, hepatitis B/C, liver cirrhosis, gastritis, ulcer, colon polyps, benign breast disease, uterine fibroids, hyperlipidemia*

ψ Adjusted for all other variables in the table

3.3.3. Breast cancer screening

Variables associated with breast cancer screening participation during 2020 are presented in table 3.8. Women having higher household income, higher education, living in the urban (compared with metropolitan cities) or having comorbidities were more likely to undergone screening in multivariable model. Also, those disagreed that cancer screening can help detect early and cure cancer, were less likely to participate in screening (OR, 0.34; 95% CI, 0.20-0.59). The excess fear of COVID-19 over cancer did not significantly affect people's engagement in screening in both univariable and multivariable models.

Table 3. 8 Factors associated with breast cancer screening during the pandemic

	Univariable		Multivariable[ψ]	
	OR (95% CI)	**p value**	**aOR (95% CI)**	**p value**
Age group				
40-49	1 (ref)		1 (ref)	
50-59	1.17 (0.86-1.6)	0.31	1.26 (0.89-1.78)	0.19
60-74	0.76 (0.56-1.02)	0.07	1.14 (0.76-1.72)	0.53
Household income level				
Below 2,000,000 KRW	1 (ref)		1 (ref)	
2,000,000-3,990,000 KRW	**1.92 (1.27-2.9)**	**0.002**	**1.6 (1.01-2.54)**	**0.045**
4,000,000 KRW and above	**2.36 (1.61-3.48)**	**<0.001**	**1.65 (1.01-2.71)**	**0.046**
Education level				
Middle school or below	1 (ref)		1 (ref)	
High school	**1.86 (1.33-2.6)**	**<0.001**	1.5 (0.98-2.31)	0.06
Undergraduate and above	**2.24 (1.53-3.29)**	**<0.001**	**2.04 (1.19-3.47)**	**0.01**
Residential area				
Metropolitan city	1 (ref)		1 (ref)	
Urban	**1.54 (1.19-1.99)**	**0.001**	**1.68 (1.28-2.2)**	**<0.001**
Rural	1 (0.64-1.55)	0.997	1.39 (0.87-2.25)	0.17
Family history of cancer				
No	1 (ref)		1 (ref)	
Yes	1.23 (0.87-1.74)	0.23	1.32 (0.92-1.91)	0.13
Cancer screening helps detect early and cure cancer?				
Agree	1 (ref)		1 (ref)	
Disagree	**0.34 (0.2-0.57)**	**<0.001**	**0.34 (0.2-0.59)**	**<0.001**
Self-perceived general health status				
Good	1 (ref)		1 (ref)	
Neutral	0.78 (0.6-1.02)	0.07	0.82 (0.61-1.09)	0.18
Bad	**0.44 (0.24-0.82)**	**0.01**	0.52 (0.26-1.05)	0.07
Comorbidities				
No	1 (ref)		1 (ref)	
Yes	**1.29 (1.01-1.65)**	**0.04**	**1.49 (1.13-1.98)**	**0.01**
Smoking status				
Nonsmoker				
Former smoker	1.07 (0.43-2.67)	0.88	0.96 (0.36-2.58)	0.94
Current smoker	0.75 (0.24-2.3)	0.61	0.58 (0.18-1.85)	0.35
More fear of Coronavirus or cancer				
More fear of cancer	1 (ref)			
Neutral	0.88 (0.59-1.29)	0.51	0.89 (0.59-1.33)	0.56
More fear of Coronavirus	0.89 (0.68-1.16)	0.39	0.88 (0.67-1.16)	0.37

OR = Odds ratio; aOR = adjusted odds ratio; CI = Confidence interval

** Comorbidities included either of the following conditions: hypertension, diabetes, tuberculosis, hepatitis B/C, liver cirrhosis, gastritis, ulcer, colon polyps, benign breast disease, uterine fibroids, hyperlipidemia*

[ψ] Adjusted for all other variables in the table

3.3.4. Cervical cancer screening

Table 3.9 displays the variables associated with cervical cancer screening participation during 2020. Women at older ages, having higher household income, or living in the urban (compared with metropolitan cities) were more likely to participate in screening. Besides, those disagreed that belief that cancer screening can help detect early and cure cancer, or perceived bad health status (compared with good health status), were less likely to participate in screening. Women with higher education level, having family history of cancer, or having comorbidities were more likely to have undergone screening in only univariable but not in multivariable model. The excess fear of COVID-19 over cancer significantly hampered women's participation in cervical cancer screening in both univariable (OR, 0.79; 95% CI, 0.64-0.98) and multivariable model (OR, 0.76; 95% CI, 0.61-0.95).

Table 3. 9 Factors associated with cervical cancer screening during the pandemic

	Univariable		Multivariable[ψ]	
	OR (95% CI)	**p value**	**aOR (95% CI)**	**p value**
Age group				
Under 40	1 (ref)		1 (ref)	
40-49	**2.11 (1.6-2.77)**	**<0.001**	**2.1 (1.57-2.81)**	**<0.001**
50-59	**2.18 (1.66-2.86)**	**<0.001**	**2.21 (1.6-3.06)**	**<0.001**
60-74	1.26 (0.97-1.63)	0.09	**1.61 (1.09-2.36)**	**0.02**
Household income level				
Below 2,000,000 KRW	1 (ref)		1 (ref)	
2,000,000-3,990,000 KRW	**1.7 (1.15-2.52)**	**0.01**	**1.63 (1.05-2.52)**	**0.03**
4,000,000 KRW and above	**1.91 (1.31-2.77)**	**0.001**	1.55 (0.98-2.44)	0.06
Education level				
Middle school or below	1 (ref)		1 (ref)	
High school	**1.66 (1.19-2.31)**	**0.003**	1.23 (0.82-1.86)	0.32
Undergraduate and above	1.38 (0.99-1.92)	0.06	1.42 (0.88-2.28)	0.15
Residential area				
Metropolitan city	1 (ref)		1 (ref)	
Urban	**1.37 (1.12-1.67)**	**0.003**	**1.4 (1.14-1.73)**	**0.002**
Rural	0.83 (0.56-1.23)	0.35	0.9 (0.59-1.36)	0.61
Family history of cancer				
No	1 (ref)		1 (ref)	
Yes	**1.34 (1-1.8)**	**0.048**	1.31 (0.96-1.79)	0.09
Cancer screening helps detect early and cure cancer?				
Agree	1 (ref)		1 (ref)	
Disagree	**0.48 (0.32-0.74)**	**0.001**	**0.49 (0.32-0.77)**	**0.002**
Self-perceived general health status				
Good	1 (ref)		1 (ref)	
Neutral	1.07 (0.86-1.33)	0.53	1.02 (0.79-1.3)	0.9
Bad	**0.37 (0.18-0.76)**	**0.01**	**0.37 (0.17-0.79)**	**0.01**
Comorbidities				
No	1 (ref)		1 (ref)	
Yes	**1.34 (1.09-1.65)**	**0.01**	**1.24 (0.96-1.6)**	**0.1**
Smoking status				
Nonsmoker	1 (ref)		1 (ref)	
Former smoker	0.73 (0.38-1.42)	0.36	0.82 (0.41-1.63)	0.58
Current smoker	1 (0.4-2.46)	0.995	0.83 (0.33-2.11)	0.7
More fear of Coronavirus or cancer				
More fear of cancer	1 (ref)		1 (ref)	
Neutral	0.87 (0.64-1.19)	0.38	0.86 (0.63-1.19)	0.37
More fear of Coronavirus	**0.79 (0.64-0.98)**	**0.03**	**0.76 (0.61-0.95)**	**0.02**

OR = Odds ratio; aOR = adjusted odds ratio; CI = Confidence interval

** Comorbidities included either of the following conditions: hypertension, diabetes, tuberculosis, hepatitis B/C, liver cirrhosis, gastritis, ulcer, colon polyps, benign breast disease, uterine fibroids, hyperlipidemia*

ψ Adjusted for all other variables in the table

3.4. Sensitivity analysis

Consistent with the main results on total survey population, the excess fear of COVID-19 over cancer did not show significant effect on health check-ups participation in those who already had schedule (OR, 0.84; 95% CI, 0.67-1.05), however respondents with more fear of Coronavirus compared with lung cancer showed a significant decrease in the odds of attendance, by nearly 27% in our multivariable model (OR, 0.73; 95% CI, 0.58-0.92).

After recategorizing the fear of COVID-19 compared with cancer, those with more fear of COVID-19 consistently showed significantly decreased likelihood of participation in health check-ups (OR, 0.83; 95% CI, 0.70-0.99 and OR, 0.78; 95% CI, 0.65-0.94), and gastric cancer screening (OR, 0.79; 95% CI, 0.63-0.98), but not for breast cancer (OR, 0.98; 95% CI, 0.73-1.33) and cervical cancer screening (OR, 0.80; 95% CI, 0.63-1.03). When subdividing the fear by 5 groups, the odds of screening participation were strongly decreased in those perceived more fear of coronavirus (4-5 points) compared with those perceived more fear of cancer (4-5 points), respectively by 47%, 50%, 49%, 39% for health check-ups, gastric cancer, breast cancer, and cervical cancer screening, after adjusting for other covariates. A test for trend showed that the p value was less than 0.05 in all these 4 models (table 3.10).

Table 3. 10 Sensitivity analysis using multivariable logistic regression: Re-categorization of the COVID-19 fear by 5 groups

	Health checkups				**Gastric cancer**		**Breast cancer**		**Cervical cancer**	
	aOR (95% CI)	p value	aOR (95% CI)	p value	aOR (95% CI)	p value	aOR (95% CI)	p value	aOR (95% CI)	p value
Gender										
Male	1 (ref)		1 (ref)		1 (ref)					
Female	1.08 (0.88-1.31)	0.48	1.06 (0.86-1.29)	0.59	1.04 (0.81-1.33)	0.79				
Age group										
20-39									1 (ref)	
40-49	1 (ref)		1 (ref)		1 (ref)		1 (ref)		**2.11 (1.58-2.82)**	**<0.001**
50-59	**1.25 (1.04-1.51)**	**0.02**	**1.25 (1.03-1.51)**	**0.02**	1.24 (0.98-1.57)	0.08	1.25 (0.89-1.77)	0.2	**2.22 (1.6-3.07)**	**<0.001**
60-74	**1.31 (1.04-1.64)**	**0.02**	**1.29 (1.03-1.62)**	**0.03**	1.25 (0.94-1.66)	0.12	1.15 (0.76-1.74)	0.5	**1.62 (1.1-2.38)**	**0.01**
Household income level										
Below 2,000,000 KRW	1 (ref)		1 (ref)		1 (ref)		1 (ref)		1 (ref)	
2,000,000-3,990,000 KRW	0.96 (0.72-1.28)	0.8	0.95 (0.72-1.27)	0.74	1.4 (1-1.97)	0.05	**1.63 (1.03-2.59)**	**0.04**	**1.62 (1.05-2.52)**	**0.03**
4,000,000 KRW and above	1.01 (0.74-1.36)	0.97	1 (0.74-1.36)	0.997	**1.56 (1.08-2.25)**	**0.02**	1.61 (0.98-2.66)	0.06	1.53 (0.97-2.42)	0.07
Education level										
Middle school or below	1 (ref)		1 (ref)		1 (ref)		1 (ref)		1 (ref)	
High school	1.1 (0.85-1.42)	0.46	1.08 (0.84-1.39)	0.54	1.19 (0.87-1.64)	0.27	1.54 (1-2.37)	0.05	1.24 (0.82-1.88)	0.31
Undergraduate and above	1.34 (0.99-1.82)	0.06	1.31 (0.97-1.77)	0.08	1.29 (0.88-1.88)	0.19	**2.06 (1.21-3.53)**	**0.01**	1.42 (0.89-2.29)	0.15
Residential area										
Metropolitan city	1 (ref)		1 (ref)		1 (ref)		1 (ref)		1 (ref)	
Urban	1.03 (0.89-1.19)	0.72	1.03 (0.89-1.2)	0.65	**1.42 (1.18-1.72)**	**<0.001**	**1.67 (1.27-2.19)**	**<0.001**	**1.4 (1.13-1.73)**	**0.002**
Rural	0.71 (0.54-0.94)	0.02	0.71 (0.54-0.93)	0.02	1.72 (1.23-2.39)	0.001	1.45 (0.89-2.35)	0.13	0.9 (0.59-1.37)	0.63
Family history of cancer										
No	1 (ref)		1 (ref)		1 (ref)		1 (ref)		1 (ref)	
Yes	0.98 (0.8-1.2)	0.84	1 (0.82-1.22)	0.98	**1.39 (1.08-1.79)**	**0.01**	1.29 (0.89-1.86)	0.18	1.3 (0.96-1.78)	0.1
Cancer screening helps detect early and cure cancer?										
Agree	1 (ref)		1 (ref)		1 (ref)		1 (ref)		1 (ref)	
Disagree	0.85 (0.64-1.15)	0.29	0.86 (0.64-1.15)	0.3	0.73 (0.51-1.03)	0.08	**0.38 (0.22-0.66)**	**0.001**	**0.51 (0.33-0.8)**	**0.003**

Self-perceived general health status										
Good	1 (ref)		1 (ref)		1 (ref)		1 (ref)		1 (ref)	
Neutral	1.14 (0.97-1.34)	0.11	1.15 (0.97-1.35)	0.1	**0.72 (0.59-0.89)**	**0.002**	0.82 (0.61-1.1)	0.19	1.02 (0.8-1.3)	0.87
Bad	1.09 (0.73-1.63)	0.67	1.09 (0.73-1.63)	0.66	0.94 (0.58-1.53)	0.8	0.52 (0.26-1.04)	0.06	**0.37 (0.17-0.78)**	**0.01**
Comorbidities										
No	1 (ref)		1 (ref)		1 (ref)		1 (ref)		1 (ref)	
Yes	0.87 (0.74-1.02)	0.1	0.88 (0.75-1.03)	0.12	**1.48 (1.2-1.81)**	**<0.001**	**1.49 (1.12-1.98)**	**0.01**	1.23 (0.96-1.59)	0.11
Smoking status										
Nonsmoker	1 (ref)		1 (ref)		1 (ref)		1 (ref)		1 (ref)	
Former smoker	0.98 (0.79-1.23)	0.89	0.97 (0.78-1.21)	0.79	0.88 (0.67-1.16)	0.36	0.97 (0.36-2.61)	0.96	0.81 (0.41-1.61)	0.55
Current smoker	0.76 (0.57-1.01)	0.06	**0.75 (0.56-1)**	**0.048**	1.25 (0.87-1.79)	0.23	0.56 (0.17-1.77)	0.32	0.83 (0.33-2.09)	0.69
More fear of Coronavirus or cancer	p=0.0006				p=0.0006		p=0.0335		p=0.0177	
4-5 (More fear of Coronavirus)	**0.53 (0.37-0.74)**	**<0.001**			**0.5 (0.34-0.74)**	**0.001**	**0.51 (0.29-0.91)**	**0.02**	**0.61 (0.37-0.99)**	**0.04**
1-3	0.84 (0.66-1.06)	0.14			1.03 (0.77-1.39)	0.83	0.9 (0.59-1.38)	0.64	0.75 (0.53-1.04)	0.08
0 (Neutral)	0.84 (0.64-1.11)	0.22			0.9 (0.64-1.26)	0.54	0.8 (0.48-1.31)	0.37	0.81 (0.55-1.21)	0.31
1-3	**0.8 (0.64-0.99)**	**0.04**			1.1 (0.83-1.44)	0.52	0.87 (0.58-1.3)	0.49	0.93 (0.67-1.27)	0.63
4-5 (More fear of cancer)	1 (ref)		1 (ref)		1 (ref)		1 (ref)		1 (ref)	
More fear of Coronavirus or Lung cancer			p = 0.0003							
4-5 (More fear of Coronavirus)			**0.53 (0.37-0.75)**	**<0.001**						
1-3			0.88 (0.71-1.1)	0.27						
0 (Neutral)			0.93 (0.72-1.21)	0.59						
1-3			0.96 (0.78-1.17)	0.68						
4-5 (More fear of lung cancer)			1 (ref)							

aOR = adjusted odds ratio; CI = Confidence interval

**Comorbidities included either of the following conditions: hypertension, diabetes, tuberculosis, hepatitis B/C, liver cirrhosis, gastritis, ulcer, colon polyps, benign breast disease, uterine fibroids, hyperlipidemia*

Sensitivity analysis by age group (table 3.11) revealed that in those aged 40-49 years, the odds of gastric cancer screening participation were lowered by 36% in those perceived more fear of COVID-19 (OR, 0.64; 95% CI, 0.45-0.91) and by 42% in those perceived equal fear (OR, 0.58; 95% CI, 0.35-0.94), compared with those perceived more fear of cancer, while the results were not statistically significant in those aged from 50 years (OR, 0.88; 95% CI, 0.62-1.26 in those aged 50-59 years, and OR, 0.87; 95% CI, 0.63-1.20 in those aged 60-74 years). Similarly in breast cancer screening, more fear of COVID-19 was associated with almost 50% decrease in the odds of participation among those aged 40-49 years (OR, 0.50; 95% CI, 0.29-0.85), but not in others (OR, 1.27; 95% CI, 0.78-2.07 in those aged 50-59 years, and OR, 0.94; 95% CI, 0.58-1.50 in those aged 60-74 years). For cervical cancer screening, lower odds of attendance were seen with more fear of coronavirus (OR, 0.59; 95% CI, 0.44-0.80) and equal fear of the two diseases (OR, 0.63; 95% CI, 0.40-0.97) only in those aged 20-49 years and not for those aged from 50 years.

For health check-ups participation, the negative impact of the excess fear towards COVID-19 was only statistically significant in those aged 60-74 years (OR, 0.72; 95% CI, 0.55-0.94) and borderline significant in those aged 40-49 years (OR, 0.75; 95% CI, 0.56-1.02), but not present in those aged 50-59 years (OR, 1.00; 95% CI, 0.75-1.33).

Table 3. 11 Impact of the COVID-19 fear on cancer screening participation: Stratification by age group

		Age 40-49		**Age 50-59**		**Age 60-74**		**Total respondents aged ≥ 40**	
		aOR (95% CI)	p value	aOR (95% CI)	p value	aOR (95% CI)	p value	aOR (95% CI)	p value
General health check-ups	More fear of Coronavirus or lung cancer								
	More fear of lung cancer							1 (ref)	
	Neutral	0.81 (0.55-1.19)	0.28	1.09 (0.74-1.61)	0.68	1.01 (0.7-1.45)	0.96	0.96 (0.77-1.19)	0.71
	More fear of Coronavirus	0.75 (0.56-1.02)	0.07	1 (0.75-1.33)	0.999	**0.72 (0.55-0.94)**	**0.02**	**0.82 (0.7-0.96)**	**0.02**
Gastric cancer screening	More fear of Coronavirus or cancer								
	More fear of cancer							1 (ref)	
	Neutral	**0.58 (0.35-0.94)**	**0.03**	0.92 (0.56-1.52)	0.75	0.97 (0.62-1.53)	0.9	0.84 (0.64-1.11)	0.22
	More fear of Coronavirus	**0.64 (0.45-0.91)**	**0.01**	0.88 (0.62-1.26)	0.49	0.87 (0.63-1.2)	0.39	**0.81 (0.66-0.98)**	**0.03**
Breast cancer screening	More fear of Coronavirus or cancer								
	More fear of cancer							1 (ref)	
	Neutral	0.55 (0.26-1.16)	0.12	1.57 (0.74-3.33)	0.23	0.89 (0.46-1.73)	0.74	0.89 (0.59-1.33)	0.56
	More fear of Coronavirus	**0.5 (0.29-0.85)**	**0.01**	1.27 (0.78-2.07)	0.34	0.94 (0.58-1.5)	0.78	0.88 (0.67-1.16)	0.37
Cervical cancer screening	More fear of Coronavirus or cancer	**(Age 20-49)**		**(Age 50-74)**					
	More fear of cancer	1 (ref)		1 (ref)				1 (ref)	
	Neutral	**0.63 (0.4-0.97)**	**0.04**	1.35 (0.84-2.18)	0.21			0.86 (0.63-1.19)	0.37
	More fear of Coronavirus	**0.59 (0.44-0.8)**	**0.001**	1.1 (0.79-1.52)	0.59			**0.76 (0.61-0.95)**	**0.02**

aOR = adjusted odds ratio; CI = Confidence interval
Odds ratios were adjusted for gender, age, education, household income, residential area, family history of cancer, self-perceived health status, comorbidities, smoking status, attitudes towards cancer screening

3.5. High-risk individuals for lung cancer screening

A total of 210 respondents were eligible for lung cancer screening program (table 3.12). Among them, only one person was female and 23.81% were current smokers. Different from the general population, high-risk group tended to be of older age (70% were 60 years old or more), have lower household income, lower education, and have higher rate of comorbidities. The excess fear of COVID-19 over lung cancer was present in 45 (21.43%, versus 29.97% in the general public), of which only 15.56% (7 people) participated in health check-ups, whereas in the general public this figure was 30.11% (321 among 1066 people with more fear of COVID-19) (table 3.13).

Table 3. 12 Characteristics of high-risk group for lung cancer screening

	High-risk group	**Survey respondents**
n (%)	210 (5.90)	3557 (100.00)
Gender, n (%)		
Male	209 (99.52)	1757 (49.40)
Female	1 (0.48)	1800 (50.60)
Age group, n (%)		
40-59	63 (30.00)	2221 (62.44)
60-74	147 (70.00)	1336 (37.56)
Household income level, n (%)		
Below 2,000,000 KRW	20 (9.52)	355 (9.98)
2,000,000-3,990,000 KRW	112 (53.33)	1250 (35.14)
4,000,000 KRW and above	78 (37.14)	1952 (54.88)
Education level, n (%)		
Middle school or below	42 (20.00)	523 (14.70)
High school	145 (69.05)	1914 (53.81)
Undergraduate and above	23 (10.95)	1120 (31.49)
Residential area, n (%)		
Metropolitan city	96 (45.71)	1614 (45.38)
Urban	75 (35.71)	1608 (45.21)
Rural	39 (18.57)	335 (9.42)
Family history of cancer, n (%)		
No	183 (87.14)	3022 (84.96)
Yes	27 (12.86)	535 (15.04)
Cancer screening helps detect early and cure cancer?, n (%)		
Agree	205 (97.62)	3315 (93.20)
Disagree	5 (2.38)	242 (6.80)
Self-perceived general health status, n (%)		
Good	132 (62.86)	2301 (64.69)
Neutral	68 (32.38)	1126 (31.66)
Bad	10 (4.76)	130 (3.65)
Comorbidities*, n (%)		
No	85 (40.48)	2000 (56.23)
Yes	125 (59.52)	1557 (43.77)
Smoking status, n (%)		
Nonsmoker		2309 (64.91)
Former smoker	160 (76.19)	902 (25.36)
Current smoker	50 (23.81)	346 (9.73)
More fear of Coronavirus or lung cancer, n (%)		
More fear of Coronavirus	45 (21.43)	1066 (29.97)
Neutral	21 (10.00)	457 (12.85)
More fear of lung cancer	144 (68.57)	2034 (57.18)

** Comorbidities included either of the following conditions: hypertension, diabetes, tuberculosis, hepatitis B/C, liver cirrhosis, gastritis, ulcer, colon polyps, benign breast disease, uterine fibroids, hyperlipidemia*

Table 3. 13 Fear of COVID-19 versus lung cancer in lung cancer high-risk group

More fear of Coronavirus or lung cancer	**Lung cancer high-risk population (n= 210)**		**Survey respondents (n=3557)**	
	Health check-ups participants, No. (%)	**Total**	**Health check-ups participants, No. (%)**	**Total**
More fear of Coronavirus	7 (15.56)	45	321 (30.11)	1066
Neutral	6 (28.57)	21	154 (33.7)	457
More fear of lung cancer	44 (30.56)	144	690 (33.92)	2034
Total	57 (27.14)	210	1165 (32.75)	3557
P value (Chi-square test)		0.14		0.09

3.6. Reasons for not participating in health check-ups during the pandemic.

Among 2392 people who did not participate in health check-ups (67.25% of survey respondents aged ≥ 40 years), 990 (41.39%) answered that they wanted to get check-up after the COVID-19 pandemic because they did not get sick right away, while 817 (34.65%) refrained from going out or medical institutions to avoid virus infection (table 3.14).

Among 153 people in the high-risk group of lung cancer who did not participate in health check-ups, 79 (51.63%) responded that they wanted to get check-up after the COVID-19 pandemic because they did not get sick right away, and 40 people (26.14%) refrained from going out or medical institutions to avoid virus infection.

Table 3. 14 Reasons for not participating in health check-ups during the pandemic

Reasons	Survey respondents		Lung cancer high-risk group	
	Total	**% Col**	**Total**	**% Col**
In case the medical examination institution will spread the corona	356	14.88	12	7.84
Refrain from going out in case of coronavirus infection	461	19.27	28	18.30
I don't get sick right away, so I want to get it after the corona epidemic	990	41.39	79	51.63
Did not receive a call for a medical examination (no information)	363	15.18	21	13.73
Not recommended to receive health check-ups near family, workplace, etc.	150	6.27	10	6.54
I have fever or respiratory symptoms	12	0.50	0	0.00
Due to poor economic conditions such as income decrease	27	1.13	2	1.31
Others	33	1.38	1	0.65
Total	**2392**	**100.00**	**153**	**100.00**

4. Discussion

4.1. Fear of COVID-19 and cancer screening

In this cross-sectional population-based study, we observed a significant upward trend in the rates of non-participation in pre-scheduled health check-ups when the fear of COVID-19 exceeds that of cancer/ lung cancer, while the prevalence of this excess fear towards COVID-19 was approximately one third of the general public. This excess fear of COVID-19 over cancer significantly hampered engagement in cancer screening and health check-ups as shown in multivariable logistic regression. These results also raised great concerns about the direct impact on lung cancer screening when asymptomatic high-risk individuals tend to downplay their own risk of lung cancer development and attempt to avoid exposure to screening facilities.

Our findings confirmed hypothesis generated in previous investigations regarding the negative impact of COVID-19 fear on health seeking behaviors.[69] While the spread of coronavirus has forced physicians to modify usual standards of care for non-covid patients,[70] the fear of exposure to coronavirus along with the thought "bothering physicians for non-COVID-19 related symptoms" have triggered people's reluctance to visit health facilities for routine or even emergent issues.[71] Studies assessing the fear of COVID-19 and its impact have been done intensively in cancer patients because of their high vulnerability due to the immune deficiency induced by cancer and its treatment,[18,72] following by the development of specific communication strategies in this subgroup.[73] However, studies

investigating the fear in the general population and how it affected cancer screening are scarce. After resuming screening services, patients have expressed the fear of virus infection as the major reason to cancel or delay screening. Patients at UK endoscopy units have reported concerns about getting COVID-19 affecting their decision on whether to attend the procedure.[74] Similarly, study in Italy has revealed nearly 30% of patients decided not to attend endoscopy as previously scheduled due to COVID-19's fear.[20] Moreover, those with clinical symptoms tended to weigh their urgent need against the risk of virus exposure in deciding whether to seek help.[75] In a qualitative study on asymptomatic women eligible for breast cancer screening, women who chose to not attend screening considered themselves at higher risk of acquiring COVID-19 because of older age or lung issues (e.g. COPD), while some mentioned they felt their cancer risk was low based on previous screening results or having no cancer risk factors.[21] In other words, when considering attendance in screening during the pandemic, people tended to weigh their risk of contracting virus against the risk of developing cancer, based on their own personal information and experience.

From this point of view, our study assessed a specific aspect of psychology under COVID-19 circumstance - the fear of COVID-19 compared with that of cancer, particularly for lung cancer as this malignancy remains the most common and leading cause of death among cancer types in Korea, with approximately 18000 deaths in 2018 (while the total deaths from COVID-19 in Korea stayed at around 900 in 2020), utilizing a single question where people can rate their fear on a 5-point scale towards cancer or coronavirus. Such scale-based fear measurement

tools had been widely used in psychological assessment. One effective and commonly used tool during the pandemic to assess population's psychological distress was the fear of COVID-19 scale (FCV-19S) - which consists of seven items that are scored on a five-point scale (Strongly disagree - 1 point, Disagree - 2 points, Neither agree nor disagree - 3 points, Agree - 4 points, and Strongly agree - 5 points).[76] Its validity and reliability have been evaluated as acceptable in different contexts, including the Korean version.[77,78]

A previous survey in lung cancer patients in Italy reported that 21% of them were more worried about COVID-19 than their own disease, mostly in long-term survivors.[79] Meanwhile, 33.65% of our survey respondents perceived more fear of COVID-19 diagnosis than cancer, and 29.97% answered that COVID-19 was more fearful than a lung cancer diagnosis. How people perceived remains unclear and complex, particularly when the fear of a certain disease might involve not only its clinical severity, but also the fear related to risk of loved ones or socio-economic consequences, as in case of COVID-19. During the pandemic, numerous warnings through broadcasts, unceasing text message alerts and prolonged social distancing stages might altogether aggravated psychological attacks in the public, also further bolstered the belief that medical facilities are at higher risk of transmitting virus. In fact, patients have expressed their concerns of being driven by social media of COVID-19 crisis as well as the risk of infection in hospitals being magnified, thus attempted to avoid hospitals at the cost of health consequences.[75] For those receiving screening invitation in 2020, the question might become which one to accept: the risk of virus infection (with its consequences) or the risk of being

diagnosed later (with poorer outcome) if delay screening. Amid the infodemic, many might ultimately consider COVID-19 as a more dangerous and direct threat that is more real and foreseeable, rather than a small potential risk of cancer for which delayed screening was acceptable or even if diagnosed, might not be curable. Our findings highlighted that such perceptions should not be ignored since almost one third of our screening targeted population – who mostly perceived themselves at normal/ good health status – was more fearful by COVID-19 than by a cancer/ lung cancer diagnosis, and such perceptions significantly hampered their screening uptake.

This negative impact of COVID-19 fear seemed to be greater in younger ages since screening rates were the lowest among those aged 20-49 years, and the sensitivity analysis by age group also showed significantly negative impact of the excess fear of COVID-19 only in younger age group (20-49 years). It could be explained by that younger aged people tended to have less concern and willingness to engage in cancer screening, and that the COVID-19 threat appeared to be more real and direct compared with a small cancer risk at young ages, thus the excess fear of COVID-19 strongly discouraged them to visit medical facilities and attend cancer screening.

Besides, people with comorbidities tended to have more fear of COVID-19 compared with cancer. Although comorbidities did not have significant effect on health check-ups participation among the general population during the pandemic in our models, in those who already had scheduled for health check-ups, people with comorbidities were less likely to participate as scheduled, which gives support

to the hypothesis that those with comorbidities tend to perceive themselves at higher risk of virus infection and avoid visiting hospitals for unurgent health screening during the pandemic. In contrast, our study showed higher odds of cancer screening participation in those living with comorbidities, which was consistent with another study conducted in Korea,[80] but not with a recent systematic review regarding the association between comorbidities and screening participation for breast and cervical cancer.[81] These inconsistency might be due to differences in study population and methodology. Besides, those with comorbidities could have had to visit physicians more often compared with others despite the pandemic situation, thus were more likely to undergo surveillance by screening tests for either cancer diagnostic purpose or other conditions.

Gastrointestinal (GI) endoscopy was heavily affected by the COVID-19 pandemic than ever due to its high potential of virus transmission through aerosols and microdroplets generated during the procedure.[82] The situation might be even worse for endoscopy screening of gastric cancer in asymptomatic individuals since the fear of infection added barrier in existing ones such as fear of inconvenience, pain or fear of the test results. To protect patients and medical personnel, organizations from around the world have established recommendations for endoscopic practices.[83-86] These include risk stratification of patients by tracing for symptoms and pre-testing with reverse transcription-polymerase chain reaction (RT-PCR) for COVID-19 infection, followed by the implementation of several precautions such as appropriate use of personal protective equipment (PPE), mask wearing, negative pressure rooms, regular cleaning of endoscopic facilities,

follow-up of patients after the procedure… Studies have reported that with such proper establishment of safety measures, GI endoscopy appeared to be generally safe for both health care workers and patients.[87,88] Besides, safety measures for other cancer screening procedures have also been widely implemented, including social distancing and restriction in waiting rooms, enhancing hygiene, screening for symptoms and temperature checks for patients and staff, and mandatory mask wearing. However, to minimize screening delays due to the fear of virus infection, it is critical that not only screening procedures must be safe, but the target screenees should also be provided with adequate information to be reassured about their attendance.

Korea has released its own guidelines for cancer care stating that cancer screening should not be delayed in healthy subjects who were not suspected of COVID-19 infection unless there is a shortage of medical resources.[89] Certain guidelines warranted a short-term delay in cancer screening because of the immediate risks related with the COVID-19 surge,[90] however as the pandemic timeline continues to extend with the reluctance of at-risk population, following by huge backlog of patients with prolonged screening delay, we may end up inverting the progress achieved in recent years for cancer survival and mortality. A modelling study in UK, taking into account three different scenarios of screening operation, has estimated a 4.8% - 16.6% increase in deaths from four malignancies (breast, colorectum, lung, and esophagus) within 5 years after diagnosis, corresponding to 3291-3621 additional deaths as a result of a 12-month delay in diagnosis since the country's lockdown on March 2020.[91] Furthermore, impact of

missing a cancer screening is not the same for every population, but could be amplified among minority subgroups.[57]

Though Korea has first successfully flattened the curve in a timely manner with the aid of proactive and drastic strategies, fear and misperception of COVID-19 in the normalization state – as partly anticipated – persisted to a considerable extent in the public and significantly held back cancer prevention. From this perspective, we believe improvement of public's awareness on cancer prevention remains critical during the ongoing pandemic, and that public risk communication should be designed not to foster self-protective practices at the expense of exacerbating the fear of COVID-19, but instead to promote sustainable behavior change while reinforcing compliance with disease screening guidelines especially for cancer. On the other hand, research has shown that communication about screening and precautions during the pandemic has been ineffective and inconsistent across screening units, since some people received comprehensive information about safety measures, some received 'normal' communication while some others received confusing or no information at all.[21] Therefore, it is vital that patients are well communicated about safety updates in screening procedures, and that the risk of a late cancer diagnosis is far more outweigh the risk of virus infection at screening units. Mass media, internet, and other virtual tools such as telehealth should be effectively utilized to emphasize screening importance in the recovering phase of the pandemic and encourage more people to attend screening. Delivery of appropriate messages when operating cancer screening to promote accurate perception regarding disease risks and severity will be the key to prevent

graver consequences of screening delays as the COVID-19 pandemic is still far from over.

4.2. Lung cancer screening

To tackle the high mortality rate from lung cancer, Korea was the first country in the world to introduce nationwide lung cancer screening program, with 90% financial support from The National Health Insurance Service (NHIS). Although previously reported feasibility pilot study - The Korean Lung Cancer Screening Project (K-LUCAS) – showed promising results, several challenges remained affecting the effectiveness of the program including refusal of screening in high-risk group and poor compliance of follow-up diagnostic procedure among individuals with abnormal results.[55] Furthermore, high socio-economic status (SES) seems to dominate among screening participants while most heavy smokers belong to low SES group, as does lung cancer risk.[92] This raised concerns about access to lung cancer screening programs of low SES individuals and the need for strategies in effort to achieve high screening uptake especially in underserved groups as well as to improve follow-up compliance when implementing the screening program. This became even more challenging when the introduction of coronavirus has created more obstacles for lung cancer high-risk groups to receive and adhere to screening recommendations. Eligible screening subjects are usually of older age with long-term smoking history and have more underlying comorbidities compared with the general population, thus might be placed at greater risk of infection and worse health complications in the pandemic. Even though only 45

among 210 eligible lung cancer screening participants in our study perceived more fear of COVID-19 (21.43%, versus 29.97% in the general public), only 15.56% (7 people) of them participated in health check-ups, whereas this figure for the total survey respondents was almost doubled at 30.11%. This suggested that while the fear of contracting virus added another barrier to these vulnerable groups, underestimating lung cancer hazards compared with COVID-19 further discouraged them to seek help and ultimately lead to postponement of screening schedule. One study in the US reported that even after full reoperation of previous suspended screening program, the monthly number of participants remained low and the rate of those who did not show up or postpone screening schedule has significantly raised during COVID-19 period.[62] A constant number of lung cancer diagnosis was observed before and after COVID-19 outbreak in a study conducted at three Korean hospitals, most likely due to the country's drastic screening of COVID-19 and proactive triaging of suspected patients, however the proportion of NSCLC patients with advanced stages significantly increased compared with the previous years.[64] The modelling study in UK estimated a 4.8–5.3% increase in the number of lung cancer deaths up to 5 years after diagnosis, corresponding to 1235 (1220–1254) to 1372 (1343–1401) additional deaths as a result of a 12-month delay in diagnosis.[91] Therefore, under the stabilization state of COVID-19, lung cancer screening should still be prioritized and maintained to prevent downstream consequences of diagnosis delay on patients' health outcomes and mortality. Appropriate health communication to high-risk groups has been left to play central role in preserving screening effectiveness.

4.3. Strengths and limitations

Our study was the first to provide a fear assessment and quantify its effect on cancer and health screening behaviors utilizing survey questionnaire in a representative sample of the public who were targeted in cancer screening program. We examined one specific psychological aspect – fear of COVID-19 in comparison with cancer/ lung cancer – as hypothesized that people tended to weigh their fear of having a relevant disease compared with that of coronavirus infection, affecting their decisions to undergo or postpone screening.

However, this work has some limitations. First, we could not establish causal relationships due to the cross-sectional nature. Second, all information were self-reported and retrospectively collected by trained interviewers, thus recall and interviewer biases might have occurred albeit fairly small as we collected information on recent health screening experience specified only during the pandemic. Third, the fear measurement using in our study has not yet been validated in prior investigations. Lastly, due to limited information, we could not evaluate the impact of the fear and misperception on certain cancer screening services such as for colorectal, liver, and lung cancer screening. However, our findings provided important evidence for future strategies in efforts to normalize and improve cancer screening uptake amid the pandemic. Future studies should be proceeded in depth to evaluate the performance of current cancer screening programs.

5. Conclusion

Research and countermeasures on COVID-19 has been conducted at an exceptional pace including the introduction of COVID-19 vaccines in addition to the emergence of novel coronavirus variants, thus information is still rapidly evolving, further challenging health communication messaging. Excess fear of COVID-19 over cancer discouraged at-risk individuals in attending cancer screening, which may eventually lead to delayed diagnosis, poorer health outcomes and elevated cancer mortality in the long run. Our findings emphasize the need to develop appropriate health communication approach amid the ongoing pandemic, particularly for high-risk individuals targeted in cancer screening, including distress and fear assessment as well as providing adequate information to promote accurate perceived susceptibility and reduce perceived barriers, thus could effectively normalize and enhance screening compliance.

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