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Original Article

Trend analysis of process quality indicators for the Korean National Cervical Cancer Screening Program from 2005 to 2013

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ABSTRACT

Objective: This study sought to examine changes in trends for quality indicators of the population-based Korean National Cancer Screening Program (KNCSP) for cervical cancer from years 2005 to 2013.
Methods: Our study data were derived from the KNCSP database. Cervical cancer diagnosis information was ascertained through linkage with the Korean National Cancer Registry and the KNCSP database. Performance measures for cervical cancer screening were estimated, including participation rate, positive rate, crude detection rate (CDR), interval cancer rate (ICR), positive predictive value (PPV), sensitivity, and specificity. Joinpoint analysis was applied to calculate annual percentage changes (APCs) in all indicators according to socio-demographic factors.
Results: A significant increasing trend was noted in participation rates (APC=13.4%; 95% confidence interval [CI]=10.5, 16.4). PPV and specificity increased from years 2005 to 2009 and remained stable till 2013. An increasing trend was discovered in CDRs for cervical cancer in situ (APC=3.9%; 95% CI=1.0, 6.9), whereas a decreasing trend was observed in ICRs for invasive cervical cancer (APC=−2.5%; 95% CI=−4.5, −0.5). Medical Aid recipients and women older than 70 years showed the lowest participation rates, but higher CDRs and ICRs, compared to other groups. In general, most of the quality indicators for cervical cancer screening improved from 2005 to 2009 and remained stable to 2013.
Conclusion: The KNCSP for cervical cancer in Korea has improved in terms of participation rate and accuracy of the screening test. These results may be attributed to the National Quality Improvement Program for KNCSP.

Keywords: Quality Indicators, Health Care; Uterine Cervical Neoplasms; Papanicolaou Test; Mass Screening; Early Detection of Cancer

INTRODUCTION

In 2017, cervical cancer was the sixth most commonly diagnosed cancer among Korean women (age standardized incidence rate of 8.7 per 100,000 individuals). Cervical cancers have, however,

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No potential conflict of interest relevant to this article was reported.

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steadily decreased in incidence since 1999 [1]. This decrease in the incidence of cervical cancer is closely related to cervical cancer screening. Launched in 1999, the Korean National Cancer Screening Program (KNCSP) has provided cervical cancer screening free-of-charge via Papanicolaou testing (Pap smear test) for Medical Aid Program (MAP) recipients aged 30 years and older. For National Health Insurance Service (NHIS) beneficiaries, cervical cancer screening has been provided through the NHIS general health-checkup program since 1988. In 2005, the cervical cancer screening program for NHIS beneficiaries was included in the KNCSP: a Pap smear test is provided to women aged 30 years and older every 2 years at no cost [2,3].

Cervical cancer screening enables the detection of precursor lesions and early-stage cancer, and high-quality population-based cervical cancer screening programs using a Pap smear test can reduce cervical cancer incidence and mortality substantially [4]. The International Agency for Research on Cancer concluded that there is sufficient evidence indicating that screening for cervical cancer every 3–5 years between the age of 35 and 64 years via a high-quality program reduces the incidence of invasive cervical cancer (ICC) by 80% or more among screened women [5]. A recent systematic review based on cohorts and case-control studies comparing women in European countries who attended organized screening programs versus women who did not described reductions in cervical cancer mortality of 41% to 92% [6]. In Korea, under the national cervical cancer screening program, the age-standardized incidence and mortality rate of cervical cancer has decreased from 16.4 to 8.7 and from 2.6 to 1.7 per 100,000 women from 1999 to 2017, respectively [1]. Therefore, it is important to monitor, assess, and evaluate the quality of screening programs to assure their effectiveness. In 2008, the Ministry of Health and Welfare launched the National Quality Improvement Program (NQIP) for KNCSP, which aims to ensure high-quality screening tests for targeted populations. As part of the NQIP, the Korean Society for Cytopathology is in charge of nationwide quality assurance management of Pap smear tests.

The current study was conducted to examine the changes in trends for quality indicators over a period of 9 years (2005–2013) in order to assess the performance of cervical cancer screening in Korea. Further, we examined the potential impact of the NQIP on quality improvements in screening services.

MATERIALS AND METHODS

1. The KNCSP for cervical cancer

The KNCSP has provided cervical cancer screening services for women aged 30 years or over (no upper age limit) from 1999 to 2015; this has been to include women in their 20s since 2016. Invitation letters are sent to women biennially from the NHIS to invite them to undergo a Pap test at a clinic or hospital designated as a cervical cancer screening unit. The test is provided free-of-charge, and the results are sent to the participants within 15 days. In individuals with a positive Pap test, follow-up examinations by colposcopy, repeat Pap test, or human papillomavirus (HPV) test are recommended to the participants. The follow-up tests are not covered by the organized screening program, but by the NHIS. Information on the Korean organized cervical cancer screening program has been described in detail elsewhere [7].

2. Data sources

Data were obtained from the KNCSP database for cervical cancer, which contains information on MAP recipients and NHIS beneficiaries invited to participate in the cervical

cancer screening program between January 1, 2005 and December 31, 2013. Pap smear test results are available for those who underwent screening. In the KNCSP, Pap smear test results are reported using the Bethesda System: 1) negative for intraepithelial lesion or malignancy; 2) epithelial cell abnormalities, including atypical squamous cells of undetermined significance (ASC-US), atypical squamous cells-cannot exclude high-grade squamous intraepithelial lesion (ASC-H), low-grade squamous intraepithelial lesion (LSIL), high-grade squamous intraepithelial lesion (HSIL), squamous cell carcinoma (SCC), atypical glandular cell (AGC), adenocarcinoma in situ (AIS), and adenocarcinoma (ADC); and 3) other malignant neoplasms. Most Pap smear test results in the other category comprise glandular abnormalities (e.g., glandular atypia, atypical endocervical glands) [8]. In the current study, results were defined as positive if any epithelial cell abnormality was reported or if the overall test results were coded as "suspicious, follow-up required" or as "highly suggestive of malignancy, further examination required."

The final cancer diagnosis was ascertained through linkage with the Korean Central Cancer Registry (KCCR) database using unique identification numbers for each participant: the database is a nationwide hospital-based system that contains information on 95% of all newly diagnosed malignancies in Korea. Based on the International Classification of Disease, 10th Revision (ICD-10), we used data on cervical cancer in situ (CIS, ICD-10: D06) and ICC (ICD-10: C53) reported to the KCCR up to December 2014 to account for a 12-month period after the screening, so that any follow-up or diagnostic workup could be completed and the results fully reported. In the KCCR, cervical intraepithelial neoplasia (CIN) is not included in the reporting system; therefore, ICC and CIS (i.e., CIN3) were included in this study.

3. Measurement

We calculated 8 quality indicators that are most representative and common measures for assessing the performance of cervical cancer screening in Korea. The indicators are participation rate, positive rate, crude detection rate (CDR), interval cancer rate (ICR), and the sensitivity, specificity, and positive predictive value (PPV) of the screening test (**Supplementary Table 1**). After calculating participation rates, those diagnosed with any type of cancer before screening day were excluded from analysis. The positivity rate was calculated as the number of positive findings per 100 screenings. CDR was calculated as the number of ICCs or CISs detected per 1,000 screenings. ICR was estimated as the number of ICCs or CISs diagnosed within 1 year of a negative screening per 1,000 negative screenings. Sensitivity was defined as the probability of a positive Pap test result given a finding of cancer within 1 year after screening. Specificity was defined as the probability of a negative Pap test given no finding of cancer within 1 year after a screening. PPV was estimated as the number of cancer cases detected among positive Pap tests. Additionally, proportions of abnormal Pap smear tests (ASC-US/ASC-H, LSIL, HSIL, AGC, AIS/ADC/SCC) were calculated by dividing the number of abnormal results by the number of total screening results, excluding cases where Bethesda results were missing.

Insurance status was used as a proxy of the socioeconomic status of the participants, as in previous studies [7,9-11]. Socioeconomic status was classified as follows: NHI beneficiaries of high-income status (upper 50%), NHI beneficiaries of lower income status (lower 50%), and MAP recipients (extremely poor people who are unable to pay for insurance and are supported by the government) [9].

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4. Statistical analysis

In this study, we conducted time series analysis for performance indicators of cervical cancer screening from 2005 to 2013 by age and insurance status groups. Joinpoint regression (version 4.7.0.0; Statistical Methodology and Applications Branch, Surveillance Research Program, National Cancer Institute, Bethesda, MD, USA) was applied to identify significant changes in quality indicators during 2005 to 2013 by age group and insurance status, and results are expressed as annual percentage changes (APCs) and 95% confidence intervals (CIs) for each trend. The final model was selected using the permutation test method [12]. SAS software (version 9.1; SAS Institute, Inc., Cary, NC, USA) was used for all statistical calculations. With permission from the Ministry of Health and Welfare, the investigators used data maintained and de-identified by the NHIS. This study was approved by the Institutional Review Board of the National Cancer Center, Korea (approval number: NCCNCS-08-129).

RESULTS

1. Performance of the KNCSP for cervical cancer

Between 2005 and 2013, around 70 million women were invited to undergo cervical cancer screening and around 22.7 million Pap smear tests were provided. **Table 1** shows the major performance indicators of the KNCSP for cervical cancer. Indicators, excluding participation rates, were calculated for 21.9 million women (96.6%), with detailed test results among those examined. About 3.2% of all analyzed Pap smear tests were classified as positive during 2005 and 2013. Between 2005 and 2013, screen-detected CIS and ICC cases totaled 23,621, and interval CIS and ICC cases comprised 3,574. CDRs of CIS increased from 0.67 per 1,000 in

Table 1. Performance of the National Cancer Screening Program for cervical cancer in Korea, from 2005 to 2013

Characteristics	2005	2006	2007	2008	2009	2010	2011	2012	2013
No. of eligible women	6,339,831	7,418,588	7,225,299	8,104,753	8,026,010	7,663,539	8,349,355	8,461,592	8,393,242
No. of screened women	1,178,580	1,598,300	1,764,654	2,337,545	2,687,493	2,704,604	3,380,195	3,479,160	3,543,542
No. of screening results*	1,154,999	1,563,631	1,722,001	2,275,645	2,606,097	2,612,265	3,256,177	3,334,065	3,381,406
No. of positive results*	95,869	118,166	57,189	119,081	55,714	59,803	75,619	66,373	74,952
No. of CIS and ICC among positives	1,201	1,544	1,630	2,058	2,919	3,095	3,745	3,536	3,893
CIS	775	985	1,035	1,409	2,022	2,170	2,711	2,514	2,813
ICC	426	559	595	649	897	925	1,034	1,022	1,080
No. of CIS and ICC among negatives	181	258	287	389	421	453	491	539	555
CIS	82	126	157	224	220	239	269	299	307
ICC	99	132	130	165	201	214	222	240	248
ICC/CIS ratio among screened women	0.61	0.62	0.61	0.50	0.49	0.47	0.42	0.45	0.43
Participation rate (%)	18.59	21.54	24.42	28.84	33.48	35.29	40.48	41.12	42.22
Positive rate (%)	8.30	7.56	3.32	5.23	2.14	2.29	2.32	1.99	2.22
Detection rate (per 1,000)	1.04	0.99	0.95	0.90	1.12	1.18	1.15	1.06	1.15
CIS	0.67	0.63	0.60	0.62	0.78	0.83	0.83	0.75	0.83
ICC	0.38	0.36	0.35	0.26	0.34	0.35	0.32	0.31	0.32
Interval Cancer rate (per 1,000)	0.17	0.18	0.17	0.18	0.17	0.18	0.15	0.16	0.17
CIS	0.08	0.09	0.09	0.10	0.09	0.09	0.09	0.09	0.09
ICC	0.09	0.09	0.08	0.08	0.08	0.08	0.07	0.07	0.08
PPV (%)	1.25	1.30	2.85	1.73	5.24	5.18	4.95	5.33	5.19
Sensitivity (%)	86.90	85.68	85.03	84.10	87.40	87.23	88.41	86.77	87.52
Specificity (%)	91.79	92.53	96.77	94.85	97.97	97.83	97.79	98.11	97.90

CIS, cervical cancer in situ; ICC, invasive cervical cancer; PPV, positive predictive value.
*Records with any cancer diagnosed before screening day or missing value for main results were excluded.

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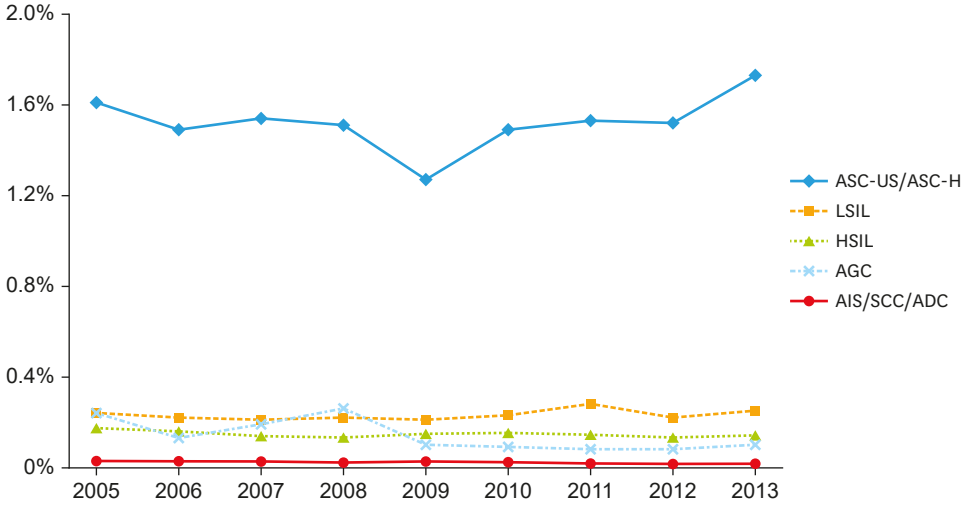

Fig. 1. Rates of abnormal Pap smear test results from 2005 to 2013. Rates were calculated by dividing the number of abnormal results from the number of screening results, excluding cases where Bethesda results were missing. ADC, adenocarcinoma; AGC, atypical glandular cell; AIS, adenocarcinoma in situ; ASC-US, atypical squamous cells of undetermined significance; HSIL, high-grade squamous intraepithelial lesion; LSIL, low-grade squamous intraepithelial lesion; SCC, squamous cell carcinoma.

2005 to 0.83 per 1,000 in 2013, while those for ICC were quite stable. Also, ICRs in the overall population were stable across the whole study period.

Fig. 1 depicts the abnormal results of Pap smear tests from 2005 to 2013. ASC (including ASC-US and ASC-H) were most prevalent. ASC rates decreased from 2005 to 2009 (APC=−4.2; 95% CI=−10.1, 2.0), but then increased from 2009 to 2013 (APC=5.5; 95% CI=0.8, 10.4). LSIL rates also showed an increasing trend from 2005 to 2013, although it was not significant (APC=1.8; 95% CI=−1.7, 5.3). However, there were decreasing trends in AGC from 0.24% in 2005 to 0.10% in 2013 (APC=−13.2; 95% CI=−22.6, −2.8), in SCC/AIS/ADC from 0.028% in 2005 to 0.016% in 2013 (APC=−7.6; 95% CI=−11.2, −3.8), and in HSIL from 0.17% in 2005 to 0.14% in 2013 (APC=−1.6; 95% CI=−3.7, 0.6).

2. Trend analysis of participation and positive rates

From 2005 to 2015, participation rates for cervical cancer screening increased significantly overall and among all subgroups (**Fig. 2** and **Supplementary Table 2**). According to Joinpoint analysis, there was a significant increasing trend in participation rates from 18.59% in 2005 to 40.48% in 2011 (APC=13.4; 95% CI=10.5, 16.4). Between 2011 and 2013, however, increase in participation rates were smaller (APC=1.4, 95% CI=−8.3, 12.0). Similar trends were observed in most of the subgroups (**Table 2**).

Regarding positive rates, significant decreasing trends were noted overall and among all subgroups from 2005 to 2013 (**Supplementary Table 3**). Positive rates decreased from 8.30% in 2005 to 2.29% in 2010 (APC=−23.8; 95% CI=−41.3, −1.1); they were then stable from 2010 to 2013 (APC=−2.1; 95% CI=−41.3, 82.6) (**Table 2**).

3. Trend analysis of crude detection and ICRs

The CDRs for cervical cancer (including CIS and ICC) did not show any significant trend in the overall study population from 2005 to 2013 (APC=2.2; 95% CI=−0.3, 4.8) (**Table 3**, **Supplementary Table 4**). However, CDRs for CIS showed a significant increasing trend

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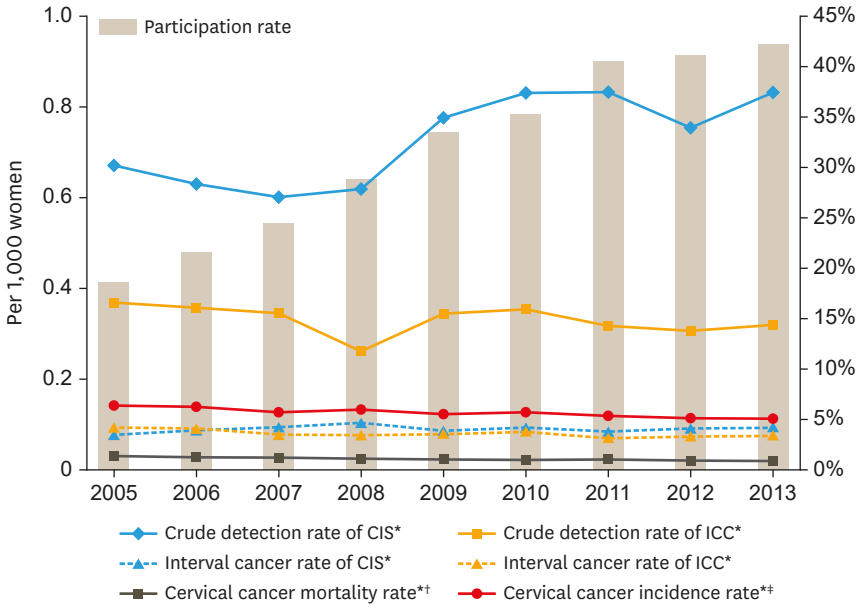

Fig. 2. Trends in cervical cancer screening participation rates, crude detection rates, interval cancer rates, age-standardized cervical cancer incidence rates, and age-standardized cervical cancer mortality rates.
CIS, cervical cancer in situ; ICC, invasive cervical cancer.
*Age-standardized rates per 1,000 women using the Korea population of 2005; †Mortality rates of uterine cervical neoplasms provided from Statistics Korea, 2018 (http://kosis.kr); ‡Incidence rates of uterine cervical neoplasms provided from annual report of cancer statistics.

Table 2. Trend analysis of participation and positive rates for 2005 to 2013

Status	Trend 1	APC	95% CI	Trend 2	APC	95% CI
Participation rate (%)						
Overall	2005–2011	13.4*	10.5, 16.4	2011–2013	1.4	−8.3, 12.0
Insurance status						
NHIS (upper 50%)	2005–2009	15.1*	5.6, 25.4	2009–2013	4.1	−1.6, 10.3
NHIS (lower 50%)	2005–2011	14.1*	10.4, 18.0	2011–2013	1.9	−10.1, 15.4
MAP	2005–2013	14.6*	11.0, 18.4			
Age (yr)						
30–39	2005–2011	27.7*	19.8, 36.1	2011–2013	0.5	−14.1, 17.6
40–49	2005–2009	17.0*	10.7, 23.7	2009–2013	6.8*	2.8, 11.0
50–59	2005–2011	10.3*	9.3, 14.5	2011–2013	0.9	−6.2, 8.6
60–69	2005–2011	12.9*	9.9, 16.0	2011–2013	3.1	−7.0, 14.2
Over 70	2005–2013	13.9*	11.7, 16.2			
Positive rate (%)						
Overall	2005–2010	−23.8*	−41.3, −1.1	2010–2013	−2.1	−41.3, 82.6
Insurance status						
NHIS (upper 50%)	2005–2010	−25.3*	−43.3, −1.8	2010–2013	−2.4	−51.7, 97.2
NHIS (lower 50%)	2005–2010	−22.6*	−40.1, −0.1	2010–2013	−2.2	−44.5, 72.4
MAP	2005–2009	−24.6*	−39.2, −6.5	2009–2013	−4.4	−29.2, 29.0
Age (yr)						
30–39	2005–2010	−25.8*	−44.0, −1.6	2010–2013	1.4	−33.5, 54.6
40–49	2005–2010	−21.8	−39.4, 1.0	2010–2013	−0.8	−47.8, 88.3
50–59	2005–2010	−24.0*	−41.8, −0.9	2010–2013	−2.5	−49.6, 88.8
60–69	2005–2010	−26.6*	−43.7, −4.3	2010–2013	−6.2	−55.7, 98.6
Over 70	2005–2010	−27.4*	−42.2, −8.8	2010–2013	−10.3	−32.1, 18.6

APC, annual percentage change; CI, confident interval; MAP, Medical Aid Program; NHIS, National Health Insurance Service.
*Indicates that the APC was significantly different from zero at alpha=0.05.

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Table 3. Trend analysis of crude detection and interval cancer rates for 2005 to 2013

Status	Trend 1	APC	95% CI	Trend 2	APC	95% CI
CDR (per 1,000)						
Overall	2005–2013	2.2	−0.3, 4.8	-	-	-
CIS	2005–2013	3.9*	1.0, 6.9	-	-	-
ICC	2005–2013	−1.3	−3.8, 1.2	-	-	-
Insurance status						
NHIS (upper 50%)	2005–2013	1.0	−1.2, 3.2	-	-	-
NHIS (lower 50%)	2005–2013	3.2*	0.1, 6.4	-	-	-
MAP	2005–2013	2.8	−1.8, 7.6	-	-	-
Age (yr)						
30–39	2005–2013	3.5	−0.3, 7.5	-	-	-
40–49	2005–2013	3.6*	1.4, 6.0	-	-	-
50–59	2005–2013	1.1	−1.9, 4.3	-	-	-
60–69	2005–2013	−0.7	−4.1, 3.0	-	-	-
Over 70	2005–2013	−1.3	−4.0, 1.5	-	-	-
ICR (per 1,000)						
Overall	2005–2013	−1.0	−2.5, 0.5	-	-	-
CIS	2005–2013	0.2	−2.3, 2.8	-	-	-
ICC	2005–2013	−2.5*	−4.5, −0.5	-	-	-
Insurance status						
NHIS (upper 50%)	2005–2013	−0.9	−3.0, 1.1	-	-	-
NHIS (lower 50%)	2005–2013	−0.8	−2.8, 1.2	-	-	-
MAP	2005–2013	−3.6	−8.9, 2.0	-	-	-
Age (yr)						
30–39	2005–2013	0.1	−5.4, 6.0	-	-	-
40–49	2005–2013	0.2	−0.8, 1.3	-	-	-
50–59	2005–2013	4.6	−3.0, 12.7	-	-	-
60–69	2005–2010	−7.8*	−13.2, −2.1	2010–2013	−11.0	−21.8, 1.4
Over 70	2005–2013	−7.5*	−12.1, −2.7	-	-	-

APC, annual percentage change; CDR, crude detection rate; CI, confident interval; CIS, cervical cancer in situ; ICC, invasive cervical cancer; ICR, interval cancer rate; MAP, Medical Aid Program; NHIS, National Health Insurance Service.
*Indicates that the APC was significantly different from zero at alpha=0.05.

(APC=3.9; 95% CI=1.0, 6.9), and CDRs for ICC showed a decreasing trend, albeit not significant (APC=−1.3; 95% CI=−3.8, 1.2) (**Fig. 2**). Women who were MAP recipients and who were older than 70 years showed higher CDRs than other groups (**Supplementary Table 4**). In subgroup analysis, women within the lower 50% income bracket of NHIS beneficiaries and those aged 40–49 years showed a significant increasing trend in CDR (APC=3.2, 95% CI=0.1, 6.4; APC=3.6; 95% CI=1.4, 6.0; respectively). Also, ICC/CIS ratio among screened women showed significantly decreasing trends (APC=−5.2; 95% CI=−6.9, −3.5). Stage distributions among ICC cases are shown in **Supplementary Table 4**. The proportion of localized and regional cancer cases increased markedly, while the proportion of cases of unknown stages decreased significantly.

The ICRs also showed no significant trend in the overall population from 2005 to 2013 (APC=−1.0; 95% CI=−2.5, 0.5) (**Table 3**, **Supplementary Table 5**). Although no significant trend was found in ICRs for CIS (APC=0.2; 95% CI=−2.3, 2.8), there was a decreasing trend in ICRs for ICC (APC=−2.5; 95% CI=−4.5, −0.5) (**Fig. 2**). Overall, women who were MAP recipients and aged 30–39 years showed higher ICRs (**Supplementary Table 5**). Meanwhile, women aged 60–69 years (APC=−7.8; 95% CI=−13.2, −2.1) and older than 70 years (APC=−7.5; 95% CI=−12.1, −2.7) showed significant decreasing trends in ICRs (**Table 3**).

4. Trend analysis of the PPV, sensitivity, and specificity of screening with the Pap smear test

PPVs for Pap smear tests increased from 1.25% in 2005 to 5.24% in 2010 (APC=36.6; 95% CI=−0.5, 97.6) and then remained stable from 2010 to 2013 (APC=−1.2; 95% CI=−39.3, 60.8) (**Table 4**, **Supplementary Table 6**). In subgroup analysis, significant increasing trends were observed in the lower 50% income bracket of NHIS beneficiaries, MAP recipients, and women older than 60 years old from 2005 to 2010 (**Table 4**).

Regarding the sensitivity of the screening test, no significant trend was observed (APC=0.3; 95% CI=−0.1, 0.8). Women aged 40–49 and 50–59 years showed a small, but significant, increasing trend in the sensitivity of the screening test (APC=0.4 during 2005–2013, and 0.8 during 2007–2013, respectively) (**Table 4**). The highest sensitivity rates were observed among women older than 70 years (92.92% in 2013) and among MAP recipients (91.85% in 2013) (**Supplementary Table 7**).

Table 4. Trend analysis of crude detection and interval cancer rates for 2005 to 2013

Status	Trend 1	APC	95% CI	Trend 2	APC	95% CI
PPV (%)						
Overall	2005–2010	36.6	−0.5, 97.6	2010–2013	−1.2	−39.3, 60.8
Insurance status						
NHIS (upper 50%)	2005–2009	47.0	−1.5, 119.4	2009–2013	3.6	−21.4, 36.5
NHIS (lower 50%)	2005–2010	36.4*	0.5, 85.0	2010–2013	−0.4	−35.4, 53.8
MAP	2005–2009	37.4*	9.4, 72.5	2009–2013	5.9	−11.4, 26.5
Age (yr)						
30–39	2005–2010	39.0	−9.0, 112.5	2010–2013	−0.9	−33.1, 46.6
40–49	2005–2010	34.5	−0.3, 81.5	2010–2013	−0.4	−39.1, 62.9
50–59	2005–2010	36.3	−1.5, 88.5	2010–2013	−3.2	−42.8, 63.9
60–69	2005–2010	40.3*	2.3, 92.3	2010–2013	−2.9	−45.2, 72.3
Over 70	2005–2009	45.2*	5.5, 99.7	2009–2013	3.6	−15.7, 27.3
Sensitivity (%)						
Overall	2005–2011	0.3	−0.1, 0.8	-	-	-
Insurance status						
NHIS (upper 50%)	2005–2013	0.1	−0.3, 0.6	-	-	-
NHIS (lower 50%)	2005–2013	0.4	−0.0, 0.9	-	-	-
MAP	2005–2013	0.5	−0.2, 1.3	-	-	-
Age (yr)						
30–39	2005–2013	0.3	−0.8, 1.3	-	-	-
40–49	2005–2013	0.4*	0.1, 0.7	-	-	-
50–59	2005–2007	−2.6	−8.3, 3.4	2007–2013	0.8*	0.0, 1.6
60–69	2005–2013	0.6	−0.2, 1.3	-	-	-
Over 70	2005–2013	0.5	−0.1, 1.1	-	-	-
Specificity (%)						
Overall	2005–2009	1.4	−0.9, 3.8	2009–2013	0.0	−0.9, 1.0
Insurance status						
NHIS (upper 50%)	2005–2009	1.5	−1.0, 4.0	2009–2013	0.0	−0.9, 1.0
NHIS (lower 50%)	2005–2013	1.4	−0.9, 3.7	2009–2013	0.0	−0.9, 1.0
MAP	2005–2007	2.8	−2.4, 8.4	2007–2013	0.2	−0.2, 0.7
Age (yr)						
30–39	2005–2009	1.7	−0.8, 4.3	2009–2013	0.0	−0.7, 0.7
40–49	2005–2009	1.4	−0.9, 3.8	2009–2013	0.0	−1.1, 1.1
50–59	2005–2009	1.4	−0.0, 3.9	2009–2013	0.0	−1.0, 1.0
60–69	2005–2009	1.5	−0.8, 3.8	2009–2013	0.1	−0.8, 1.0
Over 70	2005–2009	1.4	−0.4, 3.3	2009–2013	0.1	−0.5, 0.7

APC, annual percent change; CI, confident interval; MAP, Medical Aid Program; NHIS, National Health Insurance Service; PPV, positive predicted value.
*Indicates that the APC was significantly different from zero at alpha=0.05.

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There were consistent increasing trends in specificity among all subgroups (**Supplementary Table 8**). The specificity of the Pap smear test increased from 91.79% in 2005 to 97.90% in 2009 (APC=1.4; 95% CI=−0.9, 3.8) and then remained steady from 2009 to 2013 (APC=0.0; 95% CI=−0.9, 1.0), although these trends were not statistically significant (**Table 4**).

DISCUSSION

Our study findings provide firm evidence of considerable improvements in the performance of the cervical cancer screening program in the study period of 2005 to 2013. Overall, we noted trends of increase in participation rates, PPV and a decrease in positive rate, while CDR, ICR, and sensitivity remained stable or did not significantly change during the study period. Specificity increased from 2005 to 2009 and remained stable from 2009 to 2013.

Cervical cancer screening participation rates were quite low in 2005 (18.59%) and then rapidly increased by 2011, with an APC of 13.4% [9]. Then, from 2011 to 2013, participation rates slowed, with an APC value of 1.4%. The slowdown in the increase in participation rate may be associated with cervical cancer screening policy. In 2011, the target population for cervical cancer screening was expanded to all NHIS dependents aged 30 years and older [9]. Until 2010, only MAP recipients, NHIS beneficiaries insured through their employer, and the head of a household were invited to undergo cervical cancer screening at the age of 30 years. Other subscribers and dependents were invited to undergo cervical cancer screening from the age of 40 years.

Regarding the performance indicators for the screening test (Pap smear), we documented trends of decrease in positive rate and increase in PPV. The observed decreases in positive rates may have reflected actual decreases in positive prevalence or may have been attributed to changes in the reporting system. In the early phase of the KNCSP, the definition of positive was often based on overall findings, as there were many missing values for results under the Bethesda system; however, since the introduction of the NQIP, the fidelity of the results has increased as part of efforts to raise the quality of screening tests.

In the current study, we noted a significant decreasing trend in the rates of AGC, whereas LSIL and HSIL rates remained stable. In 2013, among the epithelial abnormality results, the proportion of ASCs was highest (1.73%), followed by LSIL (0.25%), HSIL (0.14%), AGC (0.10%), and SCC/AIS/ADC (0.016%). Even though there was an increasing number of total smear tests, the distribution of Pap smear test results stayed quite stable. ASC and AGC comprise atypical squamous and glandular cells and are diagnosed when there is not enough evidence of precursor lesions, AIS, or invasive ADC. Although the decreasing trend for AGC suggests an improvement in cytopathology, the rates of ASC-US and ASC-H still remained high and followed an increasing trend. Women who are diagnosed with AGC can experience changes in benign and precursor lesions leading to invasive cervical and other gynecological cancers [13]; moreover, AGC has also been found to be associated with a high and persistent risk of cervical cancer for up to 15 years [14].

In the current study, we observed no significant change in overall trends for CDRs and ICRs over the study period of 2005 to 2013. In subgroup analysis, however, we did find a significant increasing trend for the CDR of CIS and a decreasing trend for the ICR of ICC: trends in CDRs for ICC were not significant in this study period (APC=−1.3; 95% CI=−3.8, 1.2),

although a longer follow-up may be needed to observe a significant trend in this indicator. Additionally, ICC/CIS ratio also followed a significant decreasing trend, suggesting that the proportion of CIS cases had been increasing and that of ICC cases had been decreasing. Indirectly, during the period, the age-standardized incidence rate of cervical cancer decreased and so did the age-standardized mortality rate of cervical cancer (**Fig. 2**). Therefore, we deemed that the decreasing trend in ICRs for ICC might have had an impact on the decreasing trend in cervical cancer mortality.

Through this study, we documented a significant improvement in the quality of Pap smear tests under the national cancer screening program for cervical cancer. The quality indicators, particularly sensitivity and specificity, increased after 2005 and remained stable from 2009 to 2013. In 2013, the sensitivity of the screening test was 87.5%, and the specificity was 97.9%, which is higher than values reported in a meta-analysis [15], but comparable with a recent report on the accuracy of Pap smear tests [16]. Also, positive rates significantly declined. Meanwhile, ICRs for ICC decreased, and CDRs for CIS increased. This indicates that abnormal findings of a pre-cancerous region stage are being well identified and that invasive cancers are not being missed. These results might stem from the successful implementation of the NQIP [8], which was initiated to improve the quality of the KNCSP for 5 types of cancers, including stomach, liver, colorectum, breast, and cervical cancer. Since 2008, general hospitals, clinics, and medical centers providing screening services have been evaluated every 3 years to assess their quality, completeness of reported results, and patient satisfaction. Feedback was then given to the screening units to help them improve the quality of their services.

Even though MAP recipients showed higher APCs in participation rate, there were noticeable disparities between MAP recipients and NHIS beneficiaries in screening rate, CDR, and PPV. Although MAP recipients have received continuous support from the Korean government since the start of the screening program, screening rates for MAP recipients were much lower than those for NHIS beneficiaries. In 2013, the absolute difference in screening rate between MAP recipients and NHIS beneficiaries in the upper 50% income bracket was around 13%, and neither absolute nor relative differences showed improvements in the noted disparities. Moreover, suggesting a higher prevalence of disease, both CDRs and PPVs for MAP recipients were higher than those for NHIS beneficiaries. Previous studies in Korea have also reported higher cancer incidence among low income individuals [17], and in 2005, CDRs were higher for both invasive and cancer in situ among MAP recipients than NHIS beneficiaries [7]. These differences could be explained by a lower participation rate and higher prevalence of risk factors in MAP recipients. Accordingly, we suggest that future control policies for cervical cancer ought to consider, in addition to strategies to increase participation rates, other cancer control activities, such as HPV vaccination, among MAP recipients.

In this study, we found a significant increasing trend in CDRs among young women (30–39, 40–49 years old) and a decreasing trend in ICRs among older women (60–69 and over 70 years old). Although CDRs were highest among young (30–39 years old) and older women (over 70 years old), these 2 groups showed the lowest participation rates in cervical cancer screening. These findings are partly in line with previous studies [18,19]. Also, a higher PPV among older women group can be explained by higher proportions of HSIL and invasive cancers among these women [19].

The strengths of this study are that we linked several high credibility data sources for Korea using unique identification numbers for each participant over a long period of time

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(2005–2013). Also, this study provides information on specific quality indicators for cancer screening that will give insights into the NQIP program. However, this study also has some limitations. We could not obtain information regarding opportunistic cervical cancer screening. A previous national survey reported that 7.5% of the study population participated in opportunistic screening instead of the national screening program [20]. Second, information about hysterectomy was not available within the system, and thus, we cannot exclude those who had hysterectomy. Nevertheless, the reported rates of hysterectomy are quite low (183.25 per 100,000 women in 2013) [21]. Third, even though ASC-US and ASC-H rates reflect different aspects of the performance of the test, detailed information on ASC-US and ASC-H was not available before 2009. From 2009 to 2013, the percentage of ASC-US cases significantly increased over time, from 1.01% to 1.61% (APC=9.8, 95% CI=1.5, 18.6), whereas ASC-H decreased from 0.27% to 0.12% (APC=−18.7, 95% CI=−30.8, −4.5). With the available data and observed trends from 2009 to 2013, we expect that there might have been trends of increase in ASC-US and decreases in ASC-H throughout the whole study period. Lastly, information on follow-up procedure (e.g., colposcopy, repeated Pap test, or biopsy results) was not available; therefore, we could not evaluate important process indicators, such as diagnosis test uptake rate among Pap smear positives.

In conclusion, our study showed that national cervical cancer screening in Korea has improved in terms of not only participation rates but also the accuracy of the screening test. Continuous effort helped improve the quality of the program from 2005 to 2008, and quality indicators remained stable from 2009 to 2013. Future studies should focus on decreasing ICRs, increasing participation rates, and reducing disparities, especially among MAP recipients.

SUPPLEMENTARY MATERIALS

Supplementary Table 1
Methods for calculating the process quality indicators

Click here to view

Supplementary Table 2
Participation rates according to age group and insurance status from 2005 to 2013

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Supplementary Table 3
Positive rates according to age group and insurance status from 2005 to 2013

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Supplementary Table 4
Detection rates of cervical carcinoma in situ or invasive cervical cancer from 2005 to 2013

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Supplementary Table 5

Interval cancer rate stratified according to age group and health insurance status for 2005–2013

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Supplementary Table 6

PPVs of cervical carcinoma in situ or invasive cervical cancer from 2005 to 2013

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Supplementary Table 7

Sensitivity of screening test according to age group and health insurance status from 2005 to 2013

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Supplementary Table 8

Specificity of screening test according to age group and health insurance status from 2005 to 2013

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