表９．リスク要因別の肺癌検診の費用効果分析

	40-59 歳		60-69 歳		70-79 歳	
	C/E	ICER	C/E	ICER	C/E	ICER
喫煙者						
胸部Ｘ線	8.7M		5.2M		3.3M	
LDCT	14.2M	78.1M	6.2M	8.6M	5.1M	19.6M
非喫煙者						
胸部Ｘ線	12.7M		7.4M		4.2M	
LDCT	13.1M	14.1M	5.9M	5.2M	2.7M	1.7M

C/E； 一人年延長あたりの費用効果比、ICER；一人年延長あたりの増分費用効果比

M；100 万円

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分担研究報告書

喀痰細胞診による肺がん検診に関する研究

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研究要旨　喀痰細胞診の精度向上を目的に、prospectiveおよびretrospectiveに複数の都道府県の検診機関による同一喀痰細胞診検体の判定とその乖離状況の把握を試みた。さらに、各検診機関間で、とらえるべき喀痰所見のすり合わせを行っている。

Prospectiveには、喫煙者を対象としたCT検診時に喀痰細胞診によるスクリーニングを実施した。鹿児島県で作成した喀痰細胞診標本を宮城県、福島県、千葉県、新潟県などの検診機関の協力を得て、スクリーンングする体制を整えた。しかしながら、各地区における通常業務の間に行うため、作業の進行には時間を要している。

Retrospectiveには、複数の都道府県の検診機関で過去にC判定以上に判定された喀痰細胞診標本を収集し、これをブラインドにて複数の都道府県の検診機関で再判定を行った。施設間で判定結果の異なるものも複数検体において見られ、今後、喀痰所見把握のための具体的な討論・協議を予定している。

さらに、鹿児島県において施行されたCT検診の発見成績を解析し、CT検診による肺扁平上皮癌の発見状況を分析した。

A. 研究目的

喀痰細胞診は検診において扁平上皮癌特に、肺門部早期肺癌を発見するための唯一の方法であるが、肺門部扁平上皮癌の 90%以上が進行癌の段階で発見されている。このように日本における肺門部早期肺癌の診断状況は、満足すべき状況にない。その背景には喫煙率低下による疾患構造の変化など、複数の要因が関与すると考えられているが、古くから施設間の喀痰細胞所見把握のばらつきも指摘されている。しかしながら、具体的かつ科学的にこの問題に正面から取り組んだ試みはなされていなかった。

この問題に取り組むべく、複数都道府県において prospective および retrospective に複数機関による同一標本の喀痰細胞診スクリーニングを行った。

B. 研究方法

１）複数都道府県における prospective な複数機関喀痰細胞診スクリーニング

鹿児島県内で施行される CT 検診時、喫煙者に対し、無料で喀痰細胞診への参加を求め、1 人 6 枚の細胞診断検体を作成した。これを鹿児島県内および鹿児島県外へ郵送し、スクリーニングを行った。

２）複数都道府県における retrospective な複数機関喀痰細胞診スクリーニング

複数の都道府県の検診機関で過去に C 判定以上に判定された喀痰細胞診標本を収集し、

これをブラインドにて複数の都道府県の検診機関で再判定を行った。

３）鹿児島県内 CT 検診での扁平上皮癌の発見状況

鹿児島県内で施行された低線量 CT 肺癌検診の発見癌を分析し、CT 検診による肺扁平上皮癌の発見状況をみた。

（倫理面への配慮）

複数都道府県における複数機関喀痰細胞診スクリーニングにおいては基幹施設である鹿児島大学の倫理委員会での審査・承認を得た。さらに各実施施設での倫理委員会の審査の上、承認をいただいた。

C. 研究結果

１）複数都道府県における prospective な複数機関喀痰細胞診スクリーニング

鹿児島県内で作成した細胞診検体を鹿児島県内および鹿児島県外へ郵送し、スクリーニングを行う体制に参加するボランティア施設・個人を募集し、複数の鹿児島県内の検診施設、複数の都道府県（宮城、福島、新潟、千葉、荒川区など）でのスクリーニング体制を構築した。実際に無記名の喀痰標本を郵送し、スクリーニングを行うことは可能であった。しかし、複数地区での重複したスクリーニングを行っているため、すべてのスクリーニングを終了するまでに時間を要している。

２）複数都道府県における retrospective な複数機関喀痰細胞診スクリーニング

宮城、福島、千葉、新潟、石川、大阪から過去に C 判定以上とされた喀痰細胞診標本の提供を受けた。総計 150 症例の喀痰細胞診標本をブラインド化し、上記 6 都道府県の検診機関において再判定を行った。その結果、6 機関ですべて同一の判定となった症例は 21 例 14%に留まった。

現在、各施設内での判定が終了した段階であり、今後、診断者が集合し、各症例の所見の把握の仕方、ポイントなどを協議・討論する予定である。

３）鹿児島県内 CT 検診での扁平上皮癌の発見状況

鹿児島県では、県の補助により希望者に CT 検診が施行されている。その診断成績を組織型別に検討した結果では、腺癌 47 例、扁平上皮癌 6 例、大細胞癌 2 例、小細胞癌 2 例、腺扁平上皮癌 1 例であった。腺癌のうち 13 例は IA 期であったが、扁平上皮癌 6 例のうち IA 期の症例は 1 例のみにとどまった。

D. 考察

１)複数都道府県における prospective な複数機関喀痰細胞診スクリーニング

検診における細胞診は都道府県単位で行われることが通常であり、都道府県の枠を越えたさまざまな精度管理は実質的には行われず、不介入が不文律とされてきた。しかし、今回、都道府県の枠を越えた細胞診スクリーニングを企画し、複数の都道府県の検診機関における喀痰細胞診のスクリーニング体制を組むことができた。今後、都道府県の枠を越えた精度管理が実施可能となると思われる。従来、放置されてきた盲点が、この手法により明らかにできると考えられる。しかしながら、複数地区での重複したスクリーニングを行っているため、すべてのスクリーニングを終了するまでに時間を要している。この点を含めて、今後、このシステムを一般化するためには、解決すべき課題が残っていると考えられた。

2）複数都道府県における retrospective な複数機関喀痰細胞診スクリーニング

retrospective な検討においても、過去に診断された標本を共通の場で具体的に検討する仕組みを構築することができた。retrospective な検討においては、検討対象症例数が 150 例と限定されていたため、すでにその判定結果は判明した。おどろくべきことに 6 機関とも診断結果が完全に一致したものは 150 例中 21 例 14%に留まった。今回、検討に参加した検診機関は、いずれも積極的に喀痰細胞診検診を施行し、過去の診断実績も有している。それらの診断施設間においてすら、このよう診断実績であり、日本全国の状況を推察するに、憂慮するに耐え得ない。

今後、個々の症例のどのような所見に注目すべきかなど、診断者が一堂に会しての検討を予定している。これらを通して、標準的喀痰細胞診標本を選別・作成し、全国の検診機関での実際の標本による研修を可能とすることで、がん診療の均てん化の一翼をにないうると思われた。

3）鹿児島県内 CT 検診での扁平上皮癌の発見状況

鹿児島県では、県の補助により希望者に CT 検診が施行されている。その診断成績を組織型別に検討した結果では、多くの腺癌が早期発見されていた。一方で、少数ながら、扁平上皮癌も CT により発見されていた。しかしながら、IA 期の扁平上皮癌は 1 例のみであり、CT を用いても、扁平上皮癌の早期発見は大きな課題であることが示唆された。

E. 結論

今回、都道府県の枠を越えた細胞診スクリーニングを prospective および retrospective に企画し、複数の都道府県の検診機関における喀痰細胞診のスクリーニング体制を組むことができた。その検討結果は、喀痰検診の細胞所見の把握においては、がん検診均てん化がなされていないと言わざるをえない現状であった。

今後、喀痰細胞診の細胞判定の標準化にむけた具体的な検討が必要である。すでに我々は、喀痰細胞診の判定基準の標準化を目指して、過去に診断が確定した複数の都道府県の喀痰標本の提供を受け、標準的細胞所見標本を作成し、全国に回覧することを企画し、喀痰細胞診による肺癌発見成績の向上に向けた準備に着手した。

一方で CT 検診が肺腺癌の発見に大きく関与していることは明らかであったが、同時に、扁平上皮癌を早期の段階で発見しえていない現状も明らかになった。

今後、これらの喀痰細胞診の精度向上に向けた啓蒙活動などが実際に地域における肺門部早期肺癌の発見成績、ひいては検診による肺癌発見成績の向上につながることを実証するため、モデル地域を設定し、その効果を検証する必要があると考えられた。

F. 健康危険情報

なし

G. 研究発表

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H. 知的財産権の出願・登録状況

1. 特許取得
   なし
2. 実用新案登録
   なし

3.その他
   なし

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Does removal of out-of-pocket costs for cervical and breast cancer screening work? A quasi-experimental study to evaluate the impact on attendance, attendance inequality and average cost per uptake of a Japanese government intervention

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Reducing out-of-pocket costs is known to improve mammography attendance, but an evidence gap remains concerning Pap smear testing. The Japanese government implemented a politically determined intervention to remove out-of-pocket costs for Pap smear tests and mammography attendance, costing US$148 million, in 2009. It targeted women when they reached the first year of a 5-year age group (*i.e.*, 20, 25, 30 years) with the aim of reducing attendance inequality. Our objective is to evaluate the intervention in terms of uptake and average cost per uptake for cancer screening attendance and to assess socioeconomic inequalities in cancer screening attendance pre- and postintervention. A quasi-experimental study utilizing national repeated cross sections, observed pre- and postintervention, which compared intervention and comparison groups by the Difference-in-Differences method, was conducted. Outcome measures were uptake of cancer screening attendance resulting from the intervention with average cost per uptake and broad inequality indicators for cancer screening attendance according to socioeconomic inequality. In total, 34,043 age-eligible, noninstitutionalized women were analyzed. Uptake among the overall population was 13.9% point in the age- and income-adjusted model for Pap smear and 9.8% point for mammography, with an average cost of US$139 per uptake. The intervention increased inequality indicators in Pap smear attendance (more than +100%) but decreased inequality in mammography attendance (ranging from −12.9 to −74.1%) within the intervention group. In conclusion, removing out-of-pocket costs improves female cancer screening uptake in Japan but may not be cost-saving. Although cost removal reduces inequalities in attendance for mammography, it appears to increase inequalities in Pap smear attendance.

Breast cancer is the most commonly diagnosed female cancer worldwide. Cervical cancer is the third most commonly diagnosed but is a smaller problem in Japan.[1] Every 2 years women are invited for screening in accordance with recommendations by the Japanese Advisory Committee on Cancer Screening. Women of 20 years or more (no upper age limit) are invited for cervical cancer screening (CCS) (Pap smear), and women of 40 years or more (no upper age limit) are invited for breast cancer screening (BCS) (mammography), through local municipal governments or workplace-based medical insurances.[2] Despite national cancer screening recommendations and evidence for prevention and early detection of cancer, female cancer screening (FCS) attendance rates remain low. A possible reason for this is the absence of a population-based FCS system.[3] The current system is composed of various different structures implemented by local municipalities or workplaces, each with different approaches to individual elements of the system (*e.g.*, out-of-pocket costs setting, letters of invitation, no guideline for workplace-based cancer screening).[4] FCS is performed either as part of a health checkup for residents offered by a local municipal government or a workplace-based health checkup. If housewives and unemployed women are covered by workplace-based medical insurances for entire families, they may not attend the local government residential checkups. This makes it difficult for municipal staff to select a target population for FCS and improve FCS attendance rates. In 2007, only 24.5% of women aged 20–69 years reported having CCS and 23.8% of

Key words: Pap smear, mammography, removing out-of-pocket costs, socioeconomic inequalities in cancer screening attendance, Japan
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What's new?

Out-of-pocket costs may be a barrier to cancer screening, though their removal in some countries has met with mixed results. Here, analysis of uptake, government expenditure, and socioeconomic inequalities associated with a cost-free breast and cervical cancer screening program introduced in Japan in 2009 indicates that while attendance increased for both types of screening, overall spending for the program was considerable. Furthermore, while inequalities in attendance decreased for breast cancer screening, they increased for cervical cancer screening.

women aged 50–69 years reported having BCS, within the past year.[5] These figures are considerably lower than those for other developed countries such as the USA, Canada, Germany, the Netherlands, Korea and Australia.[5]

In 2009, the Japanese government introduced a new, politically determined policy that provided cost-free CCS and BCS attendance. Although financial barriers to screening are generally reduced in most European countries where free tests are available,[6] out-of-pocket costs have been a barrier to access in the USA and Japan.[7] To increase access to BCS, interventions to reduce or eliminate out-of-pocket costs have been recommended, especially for the lower socioeconomic population, aimed at reducing socioeconomic inequality in cancer screening attendance.[7–9] However, to date, there is insufficient evidence to determine whether reducing out-of-pocket costs is effective in increasing CCS attendance, and thus, an evidence gap was identified.[7,9] Data on cost from interventions for cancer screening attendance are also limited.[7,10] This quasi-experimental study aims to fill the evidence gap that has arisen in the absence of a governmental strategy to evaluate the intervention in Japan.

Socioeconomic inequalities in mortality, morbidity and health-related behaviors, including cancer screening attendance, have been demonstrated worldwide.[11,12] Attendance levels at FCS for Japanese women in the lowest quintile of household income were approximately half those of women in the highest quintile.[13] Inequalities in cancer screening are responsible for the higher mortality rate among people of lower socioeconomic position because of the associated decrease in the chance of early detection of cancer.[14,15] Broad policy frameworks, such as the World Health Organization Commission on the Social Determinants of Health report and the Japanese health promotion plan "Healthy Japan 21 (2nd)," present moral arguments for reducing health inequalities.[16,17] In addition to improving overall attendance, addressing inequalities in uptake must remain a priority for screening programs.[18,19]

We utilized repeated cross sections as a quasi-experimental study, which includes two consecutive population-based studies of Japanese people, observed pre- and postintervention. Our objective is to evaluate uptake and average cost per uptake of the intervention on CCS and BCS attendances and to assess socioeconomic inequalities in FCS attendance pre- and postintervention.

Material and Methods

Data

We used data from pre- and postintervention cross-sectional studies: the 2007 and 2010 Comprehensive Survey of Living Conditions of People on Health and Welfare (CSLCPHW), conducted by the Japanese Ministry of Health, Labour and Welfare (MHLW).[20] The CSLCPHW collects information on health-related factors, such as cancer screening and smoking behavior, every 3 years. Out of 940,000 inhabited census tracts (sampling unit for national census in 2005), 5,440 were randomly sampled across Japan in 2007 (5,510 in 2010) for the collection of data from all household members within each census tract. Of 11,000 units (around 5,500 census tracts were further divided into 11,000 units for appropriate alignment of territory management), 2,000 units were randomly selected across Japan for the income survey. Income data were available for 23,513 (response rate: 64.8%) households in 2007 and 26,115 (72.6%) in 2010. Data were used with permission from MHLW.

Intervention and FCS attendance

The intervention was implemented from September 2009 to March 2010 across Japan and was intended to increase uptake of attendance for Pap smear or mammography. It comprised two elements. First, vouchers were distributed (usually by mail but occasionally by hand)[4] to remove out-of-pocket costs to clients, and second, the vouchers were accompanied by small media (information leaflets). All women reaching the first year in a 5-year age group were invited to attend, that is, aged 20, 25, 30, 35 and 40 years on 31 March 2009 (identified from municipal resident registries) for Pap smear and aged 40, 45, 50, 55 and 60 years for mammography.[2] The invitees themselves made appointments for the tests (although these were rarely necessary for Pap smear tests, they were often required for mammography) at any local providers. Upon presentation of the voucher, they received the FCS without out-of-pocket costs. We assembled groups of women aged ±1 and ±2 years of the intervention group as a comparison group.

Attendance for FCS was surveyed preintervention (2007) and postintervention (2010) as follows. "Have you participated in cervical (breast) cancer screening in the past 12 months? (CCS means Pap smear test; BCS means mammo graphy or breast echography.) (yes/no)." Because only cancer

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screening modalities of Pap smear and mammography were affected by the intervention and these are the most common programs in Japan,[2,4,21] we assumed that CCS means Pap smear and BCS means mammography (not echography). As the surveys were conducted in early June, "the past 12 months" could include the total intervention term.

Evaluation framework

We used a Difference-in-Differences (DID) approach[22] to evaluate the effect of the intervention on uptake of FCS attendance. Intervention effectiveness can be evaluated by comparing pre- and postscreening attendance in the intervention and comparison groups. However, because crude comparisons of pre- and postoutcomes may be contaminated by the effect of biased characteristics that differ between the two groups, we applied not only the unadjusted DID method but also the covariate-adjusted DID method[23] with a propensity score weight[24] calculated using data on potential covariates such as age and employment status, which mitigated differences in individual traits across intervention and comparison groups.

Covariates

Covariates related to cancer screening attendance were used to present characteristics of study subjects and to control for their possible confounding effects. In line with previous studies,[13,25–30] we used (*i*) household income, (*ii*) age, (*iii*) housing tenure (home-owner or not), (*iv*) employment status, (*v*) marital status (married, never married or widowed/divorced), (*vi*) household structure (living alone, single mother, couple, couple with unmarried child, three-generation family or other), (*vii*) current smoker (yes/no), (*viii*) self-rated health (excellent, very good, good, fair or poor), (*ix*) health checkup in the last year (yes/no), (*x*) regular hospital visit for major physical disease (yes/no), (*xi*) regular hospital visit for obstetric and gynecologic disease (yes/no) and (*xii*) metropolitan areas (yes/no) (see Supporting Information for detailed methods).

For household income, to adjust for family size and composition, the Organisation for Economic Co-operation and Development (OECD)-modified equivalent scale was used with a weight of 1.0 for the first adult, 0.5 for any other household member aged 14 years and over and 0.3 for each child aged below 14 years.[27,31] The study subjects were categorized into quintiles according to the equivalent household income.

Five-year categories of women aged 23–42 and 43–62 years in 2009 were analyzed for CCS and BCS, respectively. This was because women aged 20 years in 2009 were not included for CCS and those aged 40 years in 2009 were not included for BCS, as they were ineligible for cancer screening in 2007 (*e.g.*, women aged 20 years in 2009 were 18 in 2007 and 21 in 2010).

Statistical analysis

Of 34,982 women who were age eligible and had income data, 34,043 noninstitutionalized women (16,044 in 2007 and 17,999 in 2010) were analyzed in this study. The basic characteristics were tabulated according to intervention and comparison groups. The proportion of women in each intervention and comparison group who had attended FCS in the past 12 months was tabulated according to covariates. Chi-square or Fisher's exact tests (when the expected values in any of the cells of a contingency table are below 5) were used to compare the difference in subject characteristics and FCS attendance between intervention and comparison groups. The effect of the intervention on uptake of FCS attendance was estimated by the DID method with unadjusted, age- and income-adjusted and fully adjusted models.

Probability values for statistical tests were two tailed, and $p < 0.05$ was regarded as statistically significant. All statistical analyses, other than inequality indicators, were performed using SAS version 9.2 (SAS Institute, Cary, NC).

Average cost per uptake

For a brief consideration of cost, average cost per uptake[32] of FCS (equally assuming 1 uptake for each CCS and BCS attendance) was calculated by dividing total expenditure by the absolute total number estimate of FCS uptake resulting from the intervention. Total governmental expenditure for the intervention, including additional municipality staff processing costs for the intervention, was reported as 14 billion yen (US$148 million) in 2009.[2] Absolute total uptake was estimated by multiplying the unadjusted, age- and income-adjusted and fully adjusted DID point estimates by census population.[33]

Monitoring inequality indicators

To monitor and evaluate inequality in FCS attendance, attendance inequalities according to household income were calculated because income is a representative socioeconomic factor.[34] Because there is debate about inequality measurement methods, and interpretation of results can change depending on the inequality indicator used, full consideration of the broadest range of measurement was recommended.[35] Therefore, we used absolute and relative indicators of inequality[36]: rate difference, between-group variance and absolute concentration index for absolute inequality and rate ratio, index of disparity, relative concentration index, Theil index and mean log deviation for relative inequality. Detailed explanations of these indicators are given elsewhere (online Supporting Information).[37,38] As these indicators are measured on different scales, we compared the overall change in inequality by calculating the percentage change in each indicator,[36,37] using HD*calc software (version 1.2.1) from the National Cancer Institute.[39]

Results

Basic characteristics of the study subjects are shown in Table 1 (see also Supporting Information Table S1). A statistically significant difference between the intervention and comparison groups was observed in some categories. For example, employment status in 2007 for the CCS group (proportion "not working" was 28.6% for the intervention group *vs.* 32.9% for the comparison group); and marital status, health checkup and

Table 1. Basic characteristics of the study subjects

Characteristics	Cervical cancer screening group				Breast cancer screening group			
	2007		2010		2007		2010	
	Intervention (n=1,465), %	Comparison (n=5,628), %	Intervention (n=1,606), %	Comparison (n=6,146), %	Intervention (n=1,874), %	Comparison (n=7,077), %	Intervention (n=2,000), %	Comparison (n=8,247), %
Household income								
1 st (lowest) quintile	18.4	20.4	20.4	19.9	19.6	20.1	19.3	20.3
2nd quintile	21.2	19.7	19.9	20.0	19.3	20.2	20.6	19.8
3rd quintile	19.0	20.3	18.9	20.3	21.0	19.7	20.8	19.8
4th quintile	21.1	19.7	19.4	20.2	20.5	19.9	20.2	19.9
5th (highest) quintile	20.3	19.9	21.3	19.7	19.6	20.1	19.2	20.2
Age group in 2009[1]								
23–27	19.5	18.6	19.6	18.5	-	-	-	-
28–32	22.7	22.7	23.6	23.4	-	-	-	-
33–37	31.3	29.9	28.8	29.4	-	-	-	-
38–42	26.6	28.8	28.0	28.7	-	-	-	-
43–47	-	-	-	-	21.1	21.5	21.1	21.7
48–52	-	-	-	-	21.1	22.3	21.1	21.4
53–57	-	-	-	-	23.9	25.2	24.5	24.9
58–62	-	-	-	-	33.9	31.1	33.4	32.0
Home owner								
No	34.7	36.0	33.7	32.8	15.4	15.9	16.2	16.0
Yes	65.3	64.0	66.3	67.2	84.6	84.1	83.9	84.0
Employment status								
Not working	28.6*	32.9*	31.5	31.0	30.6	30.4	36.0	34.6
Small scale less than 100 employees	25.9	24.1	25.3	25.8	23.8	23.6	22.0	22.1
Medium scale 100 to 499 employees	12.7	10.9	10.7	13.0	10.3	9.5	8.7	9.3
Large scale more than 500 employees	12.4	11.2	12.6	11.4	7.6	7.3	8.9	8.9
Public office	5.8	4.6	4.4	5.0	5.1	5.0	4.3	4.2
Unknown scale	5.3	4.7	4.1	3.8	4.0	4.2	3.0	3.2
Self-employed/Others	9.0	11.4	11.0	9.7	18.6	19.9	16.7	17.5
Missing	0.3	0.3	0.3	0.3	0.1	0.1	0.6	0.2
Marital status								
Married	55.2	56.5	63.7	63.6	83.6*	83.3*	81.4	82.3
Never married	39.7	38.1	30.8	30.8	4.9	6.4	5.5	6.1
Widowed/Divorced	5.1	5.3	5.5	5.6	11.5	10.3	13.2	11.7
Household structure								
Living alone	3.8	4.8	4.0	4.0	4.8	4.8	6.5	6.2
Single mother	6.7	6.8	6.5	6.9	5.7	6.1	6.3	5.9
Couple	8.0	7.9	8.5	8.0	16.7	18.2	23.3	24.0
Couple with unmarried child	53.4	53.7	56.4	56.8	38.2	37.9	35.2	33.6
Three-generation family	21.7	20.6	18.8	18.5	22.4	21.4	16.5	17.6
Others	6.4	6.1	5.7	5.7	12.3	11.7	12.3	12.7

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Table 1. Basic characteristics of the study subjects (Continued)

Characteristics	Cervical cancer screening group				Breast cancer screening group			
	2007		2010		2007		2010	
	Intervention (n=1,465), %	Comparison (n=5,628), %	Intervention (n=1,606), %	Comparison (n=6,146), %	Intervention (n=1,874), %	Comparison (n=7,077), %	Intervention (n=2,000), %	Comparison (n=8,247), %
Current smoker								
No	78.9	79.7	78.4	79.3	83.4	82.9	78.7	80.3
Yes	18.4	17.6	15.7	15.4	11.6	11.8	9.6	9.5
Missing	2.7	2.7	5.9	5.3	5.0	5.3	11.8	10.2
Self-rated health								
Excellent	22.5	23.2	21.4	20.8	13.9	14.1	12.9*	13.0*
Very good	20.1	18.9	18.6	17.8	15.7	15.6	12.5	14.2
Good	44.5	44.5	41.3	44.1	50.6	49.6	47.5	48.4
Fair	7.6	8.9	9.6	9.3	12.1	11.9	11.6	11.2
Poor	0.8	0.9	1.3	1.2	0.9	1.3	1.7	1.0
Missing	4.6	3.7	7.8	6.9	6.9	7.5	13.9	12.2
Health checkup in the last year								
No	44.4	46.2	40.3	41.6	35.0*	32.6*	29.3	30.1
Yes	53.9	51.5	58.6	57.6	63.2	64.6	68.3	67.7
Missing	1.7	2.3	1.1	0.8	1.8	2.8	2.5	2.1
Regular hospital visit for major physical disease								
No	93.6	95.9	92.2	91.6	77.6	78.0	70.7	72.4
Yes	4.1	2.4	5.5	6.3	19.4	19.5	27.3	25.9
Missing	2.3	1.7	2.4	2.1	3.0	2.5	2.1	1.7
Regular hospital visit for obstetric and gynecologic disease								
No	95.2	95.9	95.6	96.0	96.6*	96.4*	96.7	97.2
Yes	2.5	2.4	2.0	1.9	0.4	1.1	1.3	1.1
Missing	2.3	1.7	2.4	2.1	3.0	2.5	2.1	1.7
Metropolitan areas								
No	81.9	81.7	78.5	78.3	84.4	84.4	82.4	82.7
Yes	18.1	18.3	21.5	21.7	15.6	15.6	17.7	17.3

[1]Categorized by age in 31 March 2009
Note. P values for difference between intervention and comparison groups were obtained using chi-square tests.
*P<.05 The * mark was only placed by the first covariate factor of the characteristic.

regular hospital visit for obstetric and gynecologic disease in 2007 and self-rated health in 2010 for the BCS group.

FCS attendance rates according to basic characteristics are shown in Table 2 (figures are shown in Supporting Information Table S2). In 2007, although overall CCS or BCS attendance rates did not differ significantly between the intervention and comparison groups (21.6 *vs.* 22.5% for CCS; 27.4 *vs.* 29.2% for BCS, respectively), a statistically significant difference for attendance rates between the intervention and comparison groups was observed in the 23–27 years age group (4.2 *vs.* 8.6%), fourth household income quintile (21.7 *vs.* 27.3%), not working (29.1 *vs.* 24.5%), never married (9.0 *vs.* 11.9%), and health checkup yes group (25.3 *vs.* 30.0%) for CCS, first household income quintile (14.4 *vs.* 20.0%) and three-generation family (27.1 *vs.* 32.8%) for BCS. In 2010, the intervention group had significantly higher overall attendance rates than the comparison group (43.3 *vs.* 30.3% for CCS; 43.4 *vs.* 32.5% for BCS, respectively). Similarly, most characteristic categories showed that the intervention group had significantly higher attendance rates than the comparison group, except for small sample categories such as widowed/divorced marital status, living alone and missing.

The increase and DID estimates (effect sizes) of FCS uptake (% point) from 2007 to 2010, according to household income quintile and age group, are shown in Table 3. Although the intervention group had a higher than 15%

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Table 2. Cervical and breast cancer screening attendance rates according to basic characteristics

Characteristics	Cervical cancer screening group Cervical cancer screening attendance rates 2007 Intervention (n=1,465), %	 Comparison (n=5,628) %	 2010 Intervention (n=1,606), %	 Comparison (n=6,146), %	Breast cancer screening group Breast cancer screening attendance rates 2007 Intervention (n=1,874), %	 Comparison (n=7,077), %	 2010 Intervention (n=2,000), %	 Comparison (n=8,247), %
Overall population	21.6	22.5	43.3[2]	30.3[2]	27.4	29.2	43.4[2]	32.5[2]
Household income								
1 st (lowest) quintile	20.7	17.4	39.3[2]	22.8[2]	14.4[2]	20.0[2]	33.9[2]	24.2[2]
2nd quintile	22.2	21.7	37.2[2]	25.5[2]	26.5	26.2	38.7[2]	27.5[2]
3rd quintile	20.5	22.5	45.7[2]	29.8[2]	26.0	29.8	42.5[2]	30.4[2]
4th quintile	21.7[2]	27.3[2]	44.2[2]	35.5[2]	32.2	33.2	52.0[2]	36.7[2]
5th (highest) quintile	22.6	23.7	49.7[2]	37.8[2]	37.6	36.7	49.9[2]	43.6[2]
Age group in 2009[1]								
23–27	4.2[2]	8.6[2]	33.0[2]	19.9[2]	-	-	-	-
28–32	20.1	18.9	42.7[2]	27.6[2]	-	-	-	-
33–37	23.6	26.2	46.9[2]	34.8[2]	-	-	-	-
38–42	33.2	30.4	47.2[2]	34.5[2]	-	-	-	-
43–47	-	-	-	-	26.3	27.6	50.0[2]	34.8[2]
48–52	-	-	-	-	25.5	29.7	44.7[2]	33.4[2]
53–57	-	-	-	-	29.9	29.6	43.7[2]	32.5[2]
58–62	-	-	-	-	27.4	29.5	38.2[2]	30.3[2]
Home owner								
No	27.1	24.8	45.7[2]	30.3[2]	18.3	19.2	33.4[2]	22.9[2]
Yes	18.6	21.2	42.1[2]	30.2[2]	29.0	31.0	45.3[2]	34.3[2]
Employment status								
Not working	29.1[2]	24.5[2]	43.9[2]	30.0[2]	24.4	25.1	41.6[2]	28.9[2]
Small scale less than 100 employees	19.8	20.6	44.0[2]	27.5[2]	29.0	30.3	46.1[2]	31.4[2]
Medium scale 100 to 499 employees	17.7	20.5	44.8[2]	29.6[2]	25.4	26.9	44.5[2]	36.5[2]
Large scale more than 500 employees	17.0	24.4	41.9[2]	33.2[2]	32.4	34.1	45.2	40.7
Public office	18.8	26.9	62.0[2]	44.1[2]	42.1	52.7	58.1	56.2
Unknown scale	13.0	18.9	22.7	25.2	28.0	29.1	35.0	30.4
Self-employed/Others	22.0	20.8	41.5[2]	31.4[2]	25.3	27.5	41.0[2]	29.6[2]
Missing	0.0	6.7	0.0	10.5	0.0	12.5	9.1	20.0
Marital status								
Married	30.8	29.6	51.1[2]	35.5[2]	28.6	30.6	45.2[2]	33.5[2]
Never married	9.0[2]	11.9[2]	29.3[2]	19.8[2]	19.6	18.1	37.6[2]	25.7[2]
Widowed/Divorced	20.0	22.7	30.7	28.2	21.8	24.1	34.5	29.0
Household structure								
Living alone	16.1	22.7	36.9	34.8	14.4	21.6	35.4	28.7
Single mother	15.3	17.0	32.4[2]	20.9[2]	22.6	21.0	33.6	28.0
Couple	36.8	32.7	60.6[2]	41.2[2]	28.1	28.8	44.6[2]	32.8[2]
Couple with unmarried child	23.1	22.9	43.4[2]	30.4[2]	27.1	29.2	44.7[2]	31.0[2]
Three-generation family	16.7	19.8	40.4[2]	27.8[2]	27.1[2]	32.8[2]	45.0[2]	36.0[2]
Others	16.0	21.2	42.9[2]	29.7[2]	34.8	30.5	44.3[2]	34.9[2]

Table 2. Cervical and breast cancer screening attendance rates according to basic characteristics (Continued)

	Cervical cancer screening group				Breast cancer screening group			
	Cervical cancer screening attendance rates				Breast cancer screening attendance rates			
	2007		2010		2007		2010	
Characteristics	Intervention (n=1,465), %	Comparison (n=5,628) %	Intervention (n=1,606), %	Comparison (n=6,146), %	Intervention (n=1,874), %	Comparison (n=7,077), %	Intervention (n=2,000), %	Comparison (n=8,247), %
Current smoker								
No	22.1	23.5	45.8[2]	32.7[2]	29.1	31.3	45.9[2]	35.1[2]
Yes	20.4	19.7	37.7[2]	21.8[2]	18.3	17.5	33.0[2]	19.9[2]
Missing	12.5	9.9	24.2	18.4	19.1	21.3	35.2[2]	24.1[2]
Self-rated health								
Excellent	17.6	20.6	45.6[2]	30.4[2]	23.8	28.8	43.8[2]	34.0[2]
Very good	23.4	25.4	43.1[2]	33.1[2]	28.9	31.8	44.4[2]	35.0[2]
Good	23.6	20.6	43.7[2]	30.3[2]	28.6	29.4	45.9[2]	33.7[2]
Fair	20.7	33.1	48.1[2]	31.2[2]	28.2	29.9	40.3[2]	29.8[2]
Poor	45.5	25.0	40.0	26.4	31.3	22.3	57.6[2]	23.8[2]
Missing	10.4	15.9	29.6	21.4	20.2	22.8	34.5[2]	26.4[2]
Health checkup in the last year								
No	17.8	15.2	27.0[2]	15.5[2]	5.6	4.7	14.2[2]	7.3[2]
Yes	25.3[2]	30.0[2]	55.3[2]	41.3[2]	40.2	42.7	57.3[2]	44.7[2]
Missing	0.0	0.0	0.0	2.0	0.0	2.5	6.1	1.7
Regular hospital visit for major physical disease								
No	21.4	22.2	43.9[2]	30.0[2]	27.0	28.9	42.5[2]	31.9[2]
Yes	30.0	32.6	39.8	36.4	29.2	31.3	46.2[2]	34.7[2]
Missing	11.8	11.5	26.3	24.4	25.0	21.1	39.0	24.5
Regular hospital visit for obstetric and gynecologic disease								
No	20.9	22.0	43.0[2]	29.8[2]	27.5	29.2	43.5[2]	32.4[2]
Yes	56.8	52.2	75.0	63.2	25.0	40.0	46.2	49.4
Missing	11.8	11.5	26.3	24.4	25.0	21.1	39.0	24.5
Metropolitan areas								
No	21.4	22.4	42.5[2]	29.8[2]	28.4	29.9	43.8[2]	32.8[2]
Yes	22.3	23.0	46.0[2]	32.1[2]	21.9	25.2	41.4[2]	30.9[2]

[1]Categorized by age in 31 March 2009
Note. P values for difference between intervention and comparison groups were obtained using chi-square or Fisher's exact tests.
[2]$P<.05$

point increase in FCS attendance rates (21.7% point for CCS and 16.0% point for BCS), there was a 7.8% point (95% confidence interval: 6.2–9.4) increase for CCS and 3.3% point (1.9–4.8) for BCS in the comparison group. DID estimates for overall population were 13.9% point (12.2–15.7) in the unadjusted model, 13.9% point (9.6–18.2) in the age- and income-adjusted model and 13.8% point (9.5–18.1) in the fully adjusted model for CCS and 12.7% point (10.9–14.5) in the unadjusted model, 9.8% point (5.7–13.9) in the age- and income-adjusted model and 9.8% point (5.7–13.9) in the fully adjusted model for BCS. The observed effect (uptake) according to income quintile was not proportional across the quintiles, that is, for CCS, the third income quintile had the highest DID estimate, whereas the second quintile had the lowest with nonsignificance in the covariate-adjusted models. For BCS, the first–fourth income quintiles significantly showed positive values in the DID estimates, whereas the fifth quintile did not show positive values in the covariate-adjusted models (noting wide confidence interval), that is, 5.4% point (3.5–7.3) in the unadjusted model, 0.5% point (−9.8 to 10.9) in the age- and income-adjusted model and 2.6% point (−7.8 to 13.0) in the fully adjusted model for the

Table 3. Increase of cancer screening attendance, unadjusted and covariate-adjusted Difference-in-Differences estimates and 95% confidence intervals from 2007 to 2010

	Increase (95%CI), % point		Unadjusted DID	Age- and income-adjusted DID	Fully-adjusted DID
	Intervention	Comparison	Estimate (95%CI), % point	Estimate (95%CI), % point	Estimate (95%CI), % point
Cervical cancer screening					
Overall population	21.7 (18.5–24.9)	7.8 (6.2–9.4)	13.9 (12.2–15.7)	13.9 (9.6–18.2)[1]	13.8 (9.5–18.1)[4]
Household income					
1st (lowest) quintile	18.6 (11.4–25.8)	5.4 (2.1–8.6)	13.2 (11.6–14.9)	16.9 (7.6–26.3) [2]	17.3 (7.9–26.7)[5]
2nd quintile	15.0 (8.0–22.0)	3.8 (0.4–7.3)	11.2 (9.5–12.9)	8.6 (−0.6–17.8)[2]	8.1 (−1.2–17.3)[5]
3rd quintile	25.2 (17.9–32.6)	7.3 (3.8–10.8)	17.9 (16.2–19.7)	18.0 (8.1–28.0)[2]	17.9 (7.9–27.9)[5]
4th quintile	22.6 (15.4–29.7)	8.2 (4.5–11.9)	14.4 (12.6–16.2)	11.1 (1.2–21.0)[2]	11.4 (1.5–21.2)[5]
5th (highest) quintile	27.2 (20.0–34.3)	14.1 (10.4–17.8)	13.0 (11.2–14.8)	15.2 (5.1–25.2)[2]	14.6 (4.7–24.6)[5]
Age group in 2009[7]					
23–27	28.8 (23.1–34.5)	11.3 (8.4–14.1)	17.5 (16.2–18.9)	17.8 (10.6–24.9)[3]	17.3 (10.3–24.3)[6]
28–32	22.6 (16.0–29.2)	8.6 (5.5–11.8)	14.0 (12.3–15.7)	14.2 (5.4–23.0)[3]	13.2 (4.5–21.8)[6]
33–37	23.3 (17.3–29.3)	8.7 (5.6–11.7)	14.6 (12.8–16.4)	12.6 (4.2–20.9)[3]	12.7 (4.5–21.0)[6]
38–42	14.1 (7.5–20.6)	4.0 (0.9-7.2)	10.0 (8.1–11.9)	12.2 (2.9–21.6)[3]	13.3 (4.0–22.7)[6]
Breast cancer screening					
Overall population	16.0 (13.1–19.0)	3.3 (1.9-4.8)	12.7 (10.9–14.5)	9.8 (5.7–13.9)[1]	9.8 (5.7–13.9)[4]
Household income					
1st (lowest) quintile	19.5 (13.6–25.4)	4.2 (1.3–7.2)	15.3 (13.6–16.9)	12.7 (5.2–20.3)[2]	12.6 (5.0–20.1)[5]
2nd quintile	12.2 (5.6–18.7)	1.3 (−1.9-4.4)	10.9 (9.1–12.7)	10.6 (1.8–19.4)[2]	9.3 (0.4–18.1)[5]
3rd quintile	16.6 (10.2–23.0)	0.6 (−2.6-3.9)	16.0 (14.1–17.8)	12.7 (3.8–21.6)[2]	13.7 (5.0–22.5)[5]
4th quintile	19.8 (13.0–26.5)	3.5 (0.1–6.9)	16.3 (14.4–18.2)	12.0 (2.1–21.9)[2]	11.6 (1.8–21.4)[5]
5th (highest) quintile	12.3 (5.2–19.3)	6.9 (3.4–10.3)	5.4 (3.5–7.3)	0.5 (−9.8–10.9)[2]	2.6 (−7.8–13.0)[5]
Age group in 2009[7]					
43–47	23.7 (17.2–30.1)	7.2 (4.1–10.4)	16.4 (14.6–18.3)	13.1 (4.0–22.1)[3]	12.1 (3.0–21.3)[6]
48–52	19.2 (12.8–25.6)	3.7 (0.5–6.8)	15.5 (13.6–17.3)	13.8 (4.9–22.6)[3]	13.6 (4.8–22.4)[6]
53–57	13.8 (7.7–19.9)	3.0 (0.0–5.9)	10.8 (9.0–12.6)	8.9 (0.4–17.4)[3]	10.0 (1.5–18.5)[6]
58–62	10.8 (5.8–15.9)	0.8 (−1.8-3.3)	10.1 (8.3–11.9)	5.7 (−1.2–12.7)[3]	4.8 (−2.0–11.6)[6]

[1]Adjusted for household income quintile, age group.
[2]Adjusted for age group.
[3]Adjusted for household income quintile.
[4]Adjusted for household income quintile, age group, housing tenure, employment status, marital status, household structure, current smoker, self-rated health, health checkup in the last year, regular hospital visit for major physical disease, regular hospital visit for obstetric and gynecologic disease, and metropolitan areas.
[5]Adjusted for age group, housing tenure, employment status, marital status, household structure, current smoker, self-rated health, health checkup in the last year, regular hospital visit for major physical disease, regular hospital visit for obstetric and gynecologic disease, and metropolitan areas.
[6]Adjusted for household income quintile, housing tenure, employment status, marital status, household structure, current smoker, self-rated health, health checkup in the last year, regular hospital visit for major physical disease, regular hospital visit for obstetric and gynecologic disease, and metropolitan areas.
[7]Categorized by age in 31 March 2009.
Abbreviations, DID; Difference-In-Differences, CI; confidence interval

fifth quintile. Women in the older age group generally indicated lower estimates for both CCS and BCS than the younger, with the oldest age group for BCS representing non-significant positive value in the covariate-adjusted models, that is, although the 23–27 years age group had 17.3–17.8% point of DID estimates for CCS, the 38–42 years age group had 10.0–13.3% point; although the 43–47 years age group had 12.1–16.4% point of DID estimates for BCS, the 58–62 years age group had 4.8–10.1% point.

In the calculation for average cost per uptake, using the results of the unadjusted DID estimates according to age, the absolute total number of uptakes of FCS attendance in Japan resulting from the intervention was estimated as 1.20 million. Thus, the average cost per uptake was estimated as 11,600

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yen (approximately US$123). When the age- and income-adjusted or fully adjusted DID estimates were applied, the average cost per uptake was 13,100 yen (US$139) or 13,400 yen (US$142), respectively.

Table 4 shows estimates and percentage changes of inequality indicators for FCS attendance according to household income quintile within each intervention and comparison group in 2007 and 2010. In the CCS groups all absolute and relative inequality indicators increased, with a wide range, among both the intervention and comparison groups. In the BCS comparison group, although three absolute inequality indicators slightly increased, ranging from 15.9 to 43.9%, five relative indicators did not materially change with negative value for rate ratio. In the BCS intervention group, all indicators decreased, ranging from −12.9 to −74.1%.

Discussion

The cost-removal intervention, which uses distribution of vouchers combined with small media, has increased CCS attendance by 13.9% point and BCS attendance by 9.8% point according to the age- and income-adjusted DID model in Japan, which is a developed country with a low FCS attendance rate. Using the results of income-adjusted DID estimates according to age, the absolute total number of women attending BCS in Japan as a result of the intervention was estimated as 472,000. The total number of deaths that could be avoided by the increase in BCS attendance was calculated as 461 (based on the calculations for total screening numbers required to avoid one death[40]). According to national vital statistics, 12,204 women died from breast cancer in 2010[41]; hence, the avoidable number represents 3.8% of annual cause-specific death by breast cancer. As the number needed to screen for CCS was not available, we used the detection rates for cervical cancer by CCS by age groups according to the Japanese government report for health promotion project in 2009,[42] and the number of cases detected due to the increase in CCS attendance (13.9% point) was estimated as 519. This can reduce death and preserve fertility.[43]

As described in the introduction, although out-of-pocket cost reduction has been recommended for BCS, there is a gap in the evidence as to whether such an intervention will increase attendance for CCS, especially in Asian countries.[7] This study contributes evidence to this field with special consideration of inequality and cost. Implementation of this policy needs considerable spending, with an average cost of more than US$100 per uptake. This is more expensive than most other intervention modalities for increasing FCS, such as client reminders or one-to-one education.[44,45] Previous research has shown that even small out-of-pocket costs decrease the use of preventive care services.[46] In particular, for women of low socioeconomic position, cancer screening may be an unaffordable luxury, with competing out-of-pocket medical and nonmedical expenses, including prescription drugs, dental care and eating out.[7] Elimination of out-of-pocket costs for cancer screening access might be more favorable than reduction but needs a larger budget.

The intervention not only improved overall FCS attendance but also affected the magnitude of inequality in attendance.[47] Although the intervention might increase inequality for CCS, it might decrease inequality for BCS, in accordance with existing literature.[8,47] A number of possible reasons exist for this. First, there were inequalities that had already increased before the intervention, that is, the magnitude of inequality in 2007 was small for CCS but relatively large for BCS. Therefore, inequality variations might widen for CCS but narrow for BCS. Second, related to the first point, different personal compositions, such as age, marital status and regular hospital visit, might cause a difference between CCS and BCS. Elderly affluent women might have attended BCS before the intervention. Women in the highest income quintile might therefore show a lower attendance increase for BCS resulting from the intervention than those in other quintiles. The early years of public health interventions such as FCS are often damaging in terms of health equity.[47,48] The inverse equity hypothesis of Victora *et al.*[49] proposes that affluent sections of society preferentially benefit from, or exploit, such interventions, leading to an initial increase in inequalities (early stage). Deprived sections only begin to catch up once affluent sections of society have extracted the maximum possible benefit (late stage).[50] The younger CCS group may be in the early stage of the FCS intervention (younger women might have less time for FCS due to busy schedules than older women) and the older BCS group may be in the late stage. Third, lack of knowledge about cancer is a predictor of nonattendance at cancer screening.[29] Because different levels of knowledge about FCS are expected among the CCS and BCS groups according to their different characteristics such as age, the small media intervention, often combined with cost-removal vouchers,[7] might differently influence the CCS and BCS groups. However, the impact of this is uncertain because data on the separate effects of small media were unavailable. In a previous study, the educational intervention was less effective than cost removal among the low-income population,[51] whereas lack of knowledge was a more significant reason for nonattendance than economic obstacles among the high-income population.[29,52]

In terms of inequality indicators, not only absolute but also relative inequality indicators showed consistent trends, indicating the robustness of the results for inequality trend[35] as the strength of this study. Inequality indicators can lead to contradictory conclusions on whether inequalities in health have narrowed or not.[37] In fact, relative and absolute approaches inevitably contradict each other when populations have the same proportionate reductions in risk. As the different approaches can lead to very different priorities for action, some researchers suggest absolute indicators deserve primacy.[53] All indicators provide mathematically accurate measures of the change in overall inequality among these populations, but they reflect different normative judgments about what to consider when measuring equality.[35] As 180° opposite interpretations can emerge when using only biased

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Table 4. Estimates and percent change of inequality indicators for cancer screening attendance according to household income quintile within each of intervention and comparison groups

	Intervention			Comparison		
Inequality indicators	2007 Estimate (95%CI)	2010 Estimate (95%CI)	Percent change, %	2007 Estimate (95%CI)	2010 Estimate (95%CI)	Percent change, %
Cervical cancer screening group						
Rate Difference[1]	2.06 (−4.66-8.77)	12.52 (5.03–20.01)	509.2	9.90 (6.48-13.32)	15.06 (11.46-18.67)	52.1
Between-Group Variance[1]	0.64 (−6.61-7.89)	20.18 (−2.78-43.15)	3063.8	10.25 (3.15–17.35)	32.81 (19.59-46.04)	220.1
Absolute Concentration Index[1]	0.25 (−0.95-1.45)	2.22 (0.88-3.57)	787.4	1.46 (0.86-2.07)	3.21 (2.57-3.86)	119.7
Rate Ratio	1.10 (0.80-1.50)	1.34 (1.12-1.60)	235.9	1.57 (1.34-1.84)	1.66 (1.46-1.88)	16.4
Index of Disparity	5.68 (−18.91-30.26)	16.27 (2.73-29.82)	186.7	21.93 (9.44-34.43)	24.97 (15.35-34.59)	13.8
Mean Log Deviation	0.69 (−2.99-4.37)	5.44 (−0.41-11.29)	688.5	10.48 (3.31-17.64)	18.27 (10.84-25.70)	74.4
Theil Index	0.69 (−2.98-4.36)	5.41 (−0.36-11.18)	685.6	10.24 (3.37-17.12)	18.00 (10.81-25.20)	75.7
Relative Concentration Index	1.16 (−4.43-6.76)	5.14 (2.02–8.26)	342.0	6.49 (3.82-9.16)	10.61 (8.48-12.73)	63.5
Breast cancer screening group						
Rate Difference[1]	23.16 (17.04–29.28)	18.04 (11.26-24.83)	−22.1	16.69 (13.44-19.95)	19.35 (16.20–22.49)	15.9
Between-Group Variance[1]	58.61 (29.38–87.83)	44.88 (15.43–74.34)	−23.4	33.31 (21.40–45.23)	47.95 (33.81-62.09)	43.9
Absolute Concentration Index[1]	4.12 (3.02–5.22)	3.59 (2.38-4.80)	−12.9	3.24 (2.65-3.82)	3.85 (3.28-4.41)	18.8
Rate Ratio	2.60 (1.96-3.45)	1.53 (1.30-1.81)	−66.9	1.83 (1.62-2.08)	1.80 (1.63-1.99)	−4.3
Index of Disparity	34.10 (15.52-52.68)	20.62 (8.41-32.83)	−39.5	25.64 (16.50-34.77)	31.85 (24.22–39.48)	24.2
Mean Log Deviation	46.98 (21.37–72.59)	12.17 (4.16–20.17)	−74.1	21.26 (13.32-29.19)	22.10 (15.58-28.62)	4.0
Theil Index	42.09 (21.20–62.98)	12.00 (4.23-19.77)	−71.5	20.26 (13.00–27.53)	22.27 (15.77-28.76)	9.9
Relative Concentration Index	15.05 (11.08–19.02)	8.27 (5.47-11.07)	−45.0	11.10 (9.09–13.10)	11.84 (10.09–13.58)	6.7

[1]*Absolute indicator for inequality*
Positive percent change means widening the inequality, whereas negative percent change means reducing the inequality.
Abbreviations: CI; confidence interval

indicators, we need to evaluate inequality carefully, using broad indicators.

Another strength of our study was the large sample size for general applicability, representing the total Japanese population with a small baseline (2007) difference between intervention and comparison groups. Because this study is based on repeated cross sections instead of longitudinal data, changes to one individual could not be specified. Longitudinal studies, however, have the problem that disadvantaged people are likely to leave the study.[54] In this study, all respondents with characteristics of disadvantage could be included; this study design may thus complement longitudinal studies.

There are possible limitations to this study. First, as the information was self-reported, the study might not be free from biases, especially misclassification bias.[55] As this questionnaire was not designed for evaluation of the intervention, several modalities might be included in cancer screening. However, this would not change the DID results as the intervention only affected Pap smear and mammography testing. Second, our analysis could not distinguish whether the testing was being performed for screening or diagnostic purposes. Furthermore, although both physicians' behavior and people's knowledge and attitudes toward preventive care are important determinants of FCS attendance,[29] we could not include them because no data were collected in the survey. Third, some Japanese municipalities already deliver free FCS services to all eligible residents: 6.6% for CCS and 5.9% for BCS in January 2009.[4] This may lead to underestimation of the intervention effect. Fourth, average cost per uptake was calculated without considering switching costs. Because around 20–25% of the invitees used the vouchers in 2009 according to the government report[2] and uptake was estimated to be around 10–15% in this study, it is estimated that as a result of the intervention, around 10% of the invitees switched from their past practice (*e.g.*, workplace-based FCS) to using vouchers in their community with associated opportunity costs. Although opportunity costs for switching FCS attendance (*e.g.*, absence from work to attend FCS in the community in contrast to workplace-based FCS) were not available, the switch of financial source, which may lead to overestimation on the results of average cost per uptake, should be taken into account.

In conclusion, our results suggest that removal of out-of-pocket costs could potentially make a substantial contribution to FCS uptake and reduction of inequalities in BCS delivery due to household income inequality but may not be cost-saving. Careful and thoughtful consideration of the feasibility of continuing the intervention policy in terms of benefits and costs is required. This consideration should take account of the equity perspective as well as medical and economic factors. This study adds to a growing body of literature showing that we may need to invest extra efforts in reducing inequalities in cancer screening uptake.[56] In addition to uptake levels and average cost per uptake, policymakers should carefully consider the role of inequalities in the design of screening programs, to ensure that screening attendance pathways are closely monitored from an equity perspective.[57] Judgment as to whether a particular distribution of health is just, fair or socially acceptable may guide the interpretation of the data. Policymakers and researchers must therefore pay more attention to the normative choices inherent in measurement on which they base their evaluations of current and future health policies for remedying health inequalities.[35] Although the cost-removal intervention appears to have been successful in improving overall uptake for FCS during the first year of implementation, it is essential to continue monitoring attendance rates, average cost per uptake and socioeconomic inequality for FCS as the system matures.

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