表1 肺がん検診対象者の性・年齢分布(平成22年度)

| | 40-49歳 | 50-59歳 | 60-69歳 | 70歳以上 | 計 |
|---|---|---|---|---|---|
| 男性 | 2,745,141 | 2,794,522 | 4,488,425 | 5,595,237 | 15,623,325 |
| 女性 | 3,921,416 | 4,355,873 | 6,050,323 | 8,627,773 | 22,955,385 |
| 男女計 | 6,666,557 | 7,150,395 | 10,538,748 | 14,223,010 | 38,578,710 |

表2 肺がん検診の男女別・年齢階級別受診者数・受診率(平成22年度)

| | 40-49歳 | 50-59歳 | 60-69歳 | 70歳以上 | 計 |
|---|---|---|---|---|---|
| 男性 | 195,455(7.1) | 271,220(9.7) | 898,493(20.0) | 1,283,374(22.9) | 2,648,542(17.0) |
| 女性 | 411,790(10.5) | 606,433(13.9) | 1,476,227(24.4) | 1,651,314(19.1) | 4,145,774(18.1) |
| 男女計 | 607,245(9.1) | 877,653(12.3) | 2,374,720(22.5) | 2,934,688(20.6) | 6,794,316(17.6) |

( )内は受診率(%).

表3 男女別・年齢階級別にみた医療機関個別検診受診者割合(%)(平成22年度)

| | 40-49歳 | 50-59歳 | 60-69歳 | 70歳以上 | 計 |
|---|---|---|---|---|---|
| 男性 | 0.53 | 0.41 | 0.49 | 0.62 | 0.55 |
| 女性 | 0.49 | 0.41 | 0.49 | 0.69 | 0.55 |
| 男女計 | 0.5 | 0.41 | 0.49 | 0.68 | 0.56 |

医療機関個別検診受診者数/(医療機関個別検診受診者数+集団検診受診者数)で求めた.

した推定対象者数が公開されている[2]. 全国の比較をするときはそれを用いるべきである.

現在直近の成績である平成22年度の成績を示す(表1)[3].

対象者数は38,578,710人(男性15,623,325人, 女性22,955,385人)で, これは40歳以上人口(平成22年度)の53.3%にあたる. この対象者数を基準とした年齢階級別受診率を表2に示す. 40歳以上(100歳以上も含まれる)の受診率は17.6%であった. 年齢階級別にみると60歳以上の年齢階級では20%強の受診率であったが, 60歳未満では10%前後の受診率であった.

60歳未満の年齢では職場で受診機会がなくても仕事を休んで受診する余裕がないことが住民検診の受診率が低い理由と考えられる.

検診の方式別にみると医療機関個別方式と集団方式との比はほぼ0.5前後であったが, 70歳以上では男性0.64, 女性0.71と医療機関個別方式の割合が急増した(表3). この年齢は合併症を多く有することから医療機関への親和性が高いと考えられる.

肺がん検診は年1回の経年検診でないと効果が出ないといわれており, 受診者集団の8割以上の経年受診率が望ましいとされている. 医療機関個別方式は集団方式よりも経年受診が高いこと, 年齢階級が若くなるほど経年受診率が低いことが明らかである(表4). 60歳未満の年齢階級では受診がイレギュラーで効果が期待できない.

表5に要精検以降の成績を示す. 要精検率は2.8%, 精検受診率は78.9%であった. ここでいう精検受診は要精検者から精検未受診者(精密検査を受診していないことが確認されている者)と精検結果未把握者(精密検査を受診したことは確認されているものの, その結果が把握されていないもの)を除したものと定義されている. 精検受診率は高ければ高いほどよいはずだが, それを低下せしめている理由の多くは精検未把握が多いことである.

がん発見数は4,296人で, これは肺がんの年

表4　男女別・年齢階級別・検診方式別にみた非初回割合(%)

| | | 40-49歳 | 50-59歳 | 60-69歳 | 70歳以上 | 計 |
|---|---|---|---|---|---|---|
| 男性 | 集団方式 | 53.4 | 65.7 | 68.2 | 79.2 | 71.9 |
| | 個別方式 | 39.8 | 53.5 | 60.8 | 72.4 | 64.9 |
| 女性 | 集団方式 | 53.9 | 68.1 | 73.2 | 79.2 | 72.7 |
| | 個別方式 | 40.6 | 57.1 | 66.7 | 73.1 | 66.1 |
| 男女計 | 集団方式 | 54.4 | 67.3 | 71.3 | 79.2 | 72.4 |
| | 個別方式 | 40.8 | 56.0 | 64.5 | 72.8 | 65.6 |

肺がん検診の場合，非初回は前年度受診者を指すため，非初回割合は経年受診割合と同義語である．肺がん取扱い規約によれば80%以上が望ましいとされている．

表5　肺がん検診の要精検以降のプロセス指標

| | 数 | 率 |
|---|---|---|
| 要精検者数 | 198,962 | 2.8(%) |
| 精検受診 | 154,551 | 78.9(%) |
| 精検未受診 | 17,760 | 8.9(%) |
| 精検結果未把握 | 26,651 | 13.4(%) |
| がん発見数 | 4,296 | 60.9(10万人比) |
| 原発性肺がん | 2,651 | 61.7(%) |
| I期の肺がん | 875 | 33.3(%) |

間罹患数が約9万人程度と推定される[4]ことから全罹患数の5%程度であり，妥当な成績であろう．一方原発性肺がん数はがん発見数のわずか61.7%となっている．残り38.3%が他臓器癌の肺転移とは考えられず，市町村が把握した情報に原発性肺がんの有無がはっきり書かれていないために，過小評価した数字であろう．原発性肺がんと判明したもののうちI期のがんの割合は33.3%にすぎない．これも病期不明が多いためと考えられる．

## 3　現状のまとめ

我が国の肺がん検診は普及しかつ義務化された結核検診と共存するような形で運営されてきた．結核検診の標的疾患ではない肺がんも含めた疾患がどの程度発見されているのか，といった情報は主に結核検診として行われている職場健診では収集されておらず，その精度は確認のしようがない．一方，市町村が実施主体である健康増進法に基づく肺がん検診は，曲がりなりにでも結果を収集する仕組みが存在する．今回分析に用いた平成22年度集計と前年度の21年度集計との間で集計フォーマットに大きな変化があった．‘発見されたがん’，‘発見された原発性の肺がん’，‘原発性肺がんのうちI期のがん’という3つの区分が加わったものの，今回の分析結果からは，情報の漏れが非常に多かったと考えられる．発見がんが原発性か転移性か，ということは診断・治療を行う専門病院の医師レベルでは明らかであるものの，集計を取りまとめる市町村の保健師や結果報告用紙を記入するかかりつけ医には判断ができなかったのではないかと考えられる．肺がんの場合治療にあたっては組織型やTNM分類などの詳細情報が必要であるが，検診で発見されたがんの統計としては，原発か転移か，I期かII期以上かという情報だけで十分であり，読者が専門医療機関の勤務医の立場であれば，最低その情報がわかるように市町村に返事をしていただきたい．また患者が複数の医療機関を受診して治療する場合，このような調査は漏れが生じやすくなる．転院で紹介状を発行する際は，検診の結果報告用紙も同時に手渡して次の医療機関につなげることが望ましい．

肺がん検診の受診率が低いとはいえ，40歳以上の住民というあいまいな定義では明らかに非効率的である．一回受診さえすれば効果のある検診ではなく継続的な受診行動を担保でき，かつ有効な治療法が行いうる年齢階級であるべきだ．実際の成績をみると，60歳未満の受診は非初回割合が低く，受診パターンが不規則であ

り効果は期待できない．60歳代以降に多い肺がんという疾患の特徴を考えると，肺がん検診の対象者を60-70歳代に限定することが効率的であろう．

高齢者の特に女性は集団方式よりも医療機関個別方式を多く受診していた．検診日程の縛りがなく，ほぼ毎日受診が可能な個別方式の方が受診者には便利であろう．ただし検診を専門とした集団方式に比べると個別方式での専門性は低いため質の担保が必要である．個別方式に従事する医師は肺がん検診と結核検診の違い，検診と診療の違いなどをよくよく理解したうえで臨むことが必要である．

日本の検診制度は複雑であり理解は困難である．その中で住民を対象とした肺がん検診についてはそれなりの成績が得られている．ただし対象者などの定義があいまいなために効率的な運営が図られているとはいいがたい．今後は枠組みの抜本的な整理が望まれる．

## 文　献

1) 厚生省老人保健福祉局老人保健課(監)：老人保健法による健康診査マニュアル．日本医事新報社，1994.
2) 独立行政法人国立がん研究センターがん対策情報センター：がん情報サービス．がん検診受診率データ(市区町村による地域保健・健康増進事業報告データ)．[http://ganjoho. jp/professional/statistics/statistics. html#07]
3) 厚生労働省大臣官房統計情報部：平成22年度地域保健・健康増進事業報告(健康増進編)，厚生労働統計協会，2012.
4) Matsuda A, et al: Cancer incidence and incidence rates in Japan in 2007: a study of 21 population-based cancer registries for the Monitoring of Cancer Incidence in Japan (MCIJ) project. Jpn J Clin Oncol **43**(3): 328-336, 2013.

投稿

# 市町村におけるがん検診精度管理指標の評価方法について

## －Funnel plotによる評価－

伊藤（イトウ） ゆり＊1　中山（ナカヤマ） 富雄（トミオ）＊2　山崎（ヤマザキ） 秀男（ヒデオ）＊4　津熊（ツクマ） 秀明（ヒデアキ）＊3

**目的**　健康増進法に基づき市町村が実施するがん検診事業は，各都道府県に設置された生活習慣病管理指導協議会が，その実施において適正であったかを評価することが国の指針で望まれている。がん検診の精度管理指標には，要精検率，精検受診率，がん発見率などがあり，これらの指標は「厚生労働省がん検診事業評価に関する報告書」に記された許容値等と比較することで評価されるが，自治体の規模の大きさにより各指標にばらつきが生じうるため，単純な比較には問題がある。人口規模の違いを考慮に入れた上で，各精度管理指標が極端に低い（あるいは高い）市町村を検出することができるFunnel plotを用いて，大阪府の市町村におけるがん検診の各精度管理指標について評価を行った。

**方法**　大阪府で毎年刊行している「大阪府におけるがん検診」の平成20年度の各市町村のがん検診精度管理指標を評価した。本報告では大腸がん検診を例とした。横軸を分母の値（検診受診者数や要精検者数）とし，縦軸を各精度管理指標（要精検率，精検受診率，がん発見率）の点推定値とし，市町村の散布図を描く。その上に厚生労働省のがん検診事業の評価に関する委員会で決められた許容値を水平に描き，横軸の数値に応じた縦軸の95％信頼区間および99.8％信頼区間を描いた（Funnel plot）。各市町村の規模に応じた許容値の信頼区間を基準とし，統計的に有意に逸脱していないかを評価した。全体の評価および検診の実施方式（集団・個別）別にも検討した。

**結果**　全体では男性で要精検率が統計的に有意に高い市町村が多く（21/43市町村），精検受診率は男女とも低い市町村が多かった（男性12/43，女性13/43）。要精検率は集団方式と比べて個別方式の方が，統計的に有意に高い値を示す市町村が多かった。一方，精検受診率は個別方式でのばらつきが大きく，許容値に比べて統計的に低い値を示した市町村が多かった（男性13/26，女性14/26）。集団方式では，個別方式よりもばらつきが小さく，高い精検受診率を示した市町村が多かった。

**結論**　市町村において実施されているがん検診の精度管理指標は点推定値で比較されることが多く，人口規模の違いを考慮することができなかったが，Funnel plotを用いることで，人口規模に応じた許容値の達成度を評価することが可能となった。

キーワード　がん検診，がん対策，がん検診精度管理，Funnel plot

＊１大阪府立成人病センターがん予防情報センター疫学予防課研究員　＊２同課長　＊３同センター長
＊４財団法人大阪府保健医療財団大阪がん循環器病予防センター

# Ⅰ 緒　　言

わが国においては，健康増進法に基づき，市町村の事業として，胃がん，大腸がん，肺がん，乳がん，子宮頸がん検診が実施されている。国の指針[1]では各都道府県に設置された生活習慣病管理指導協議会が市町村におけるがん検診事業が適正に実施されているかを評価することが望ましいとされている。がん検診の評価指標のうち主なものは精度管理指標（プロセス指標）とよばれ，受診率，要精検率，精検受診率，陽性反応的中度，がん発見率などがある。これらの指標は「厚生労働省がん検診事業評価に関する報告書」[2]に記された許容値や目標値と比較することで主に評価されるが，自治体の規模の大きさにより各指標にばらつきが生じうるため，単純な評価では問題がある。そこで，人口規模の違いを考慮に入れた上で，各精度管理指標が極端に低い（あるいは高い）市町村を検出するためにFunnel plotを用いて，がん検診の精度管理指標を評価する方法を提案した。本研究は，平成20年度の大阪府におけるがん検診の資料より，大阪府の市町村において実施されている便潜血検査を用いた大腸がん検診を例に，各種精度管理指標について評価を行った。

# Ⅱ 方　　法

（1） 使用した資料

大阪府では市町村で実施されたがん検診の精度管理指標をまとめたものを毎年「大阪府におけるがん検診」として刊行している。平成20年度の「大阪府におけるがん検診」[3]のデータを用いて，各市町村の大腸がん検診について，以下の精度管理指標について評価した。

要精検率＝要精検者数／受診者数＊100

精検受診率＝精検受診者数／要精検者数＊100

がん発見率＝発見がん数／受診者数＊100

（2） Funnel plotによる評価

Funnel plotはメタアナリシスにおいて各研究の標本サイズの違いを考慮に入れて，出版バイアスを評価する手法であるが，医療機関別の術後死亡率の比較[4]や地域別，国別のがん患者の生存率の比較においても用いられている[5)-7)]。Funnel plotは縦軸に評価する値（相対リスクや死亡率，生存率など）を取り，横軸に分母となる値や，それに該当する値の分散の逆数をとる。平均値またはターゲットとする目標値を水平に中心部に描き，その上下に各横軸の値（分母）に該当する95％信頼区間，および99.8％信頼区間をプロットし，曲線を描く。この曲線が漏斗状にみえるため，Funnel（漏斗）plotという。本研究においては，がん検診の精度管理指標の評価にFunnel plotを用いるため，縦軸に要精検率や精検受診率などの指標値，横軸に各指標値の分母となる数値（要精検率なら受診者数，精検受診率なら要精検者数）をとり，散布図を描き，その上に各指標値の許容値を水平に描き，横軸の数値に応じた95％信頼区間および99.8％信頼区間を描いた（図1）。各市町村の値が，Funnel plotの弧の外側（逸脱域）に位置するとき，その指標値は統計的に有意に高い（または低い）ということになる。がん検診の

図1　Funnel Plotの例（精検受診率を例に）

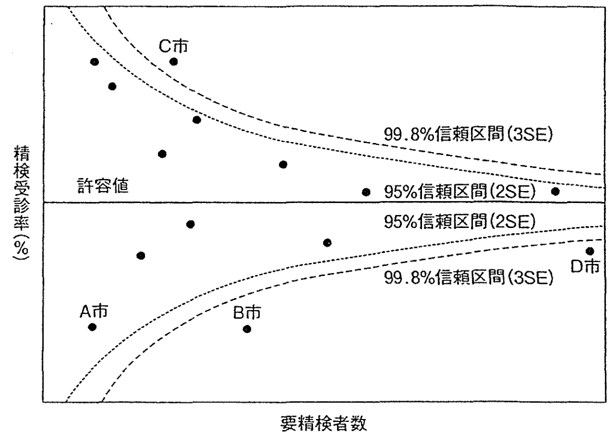



表1　大腸がん検診の精度管理指標の許容値

| | 許容値 | Funnel plotにおける逸脱域 |
|---|---|---|
| 要精検率 | 7.0％以下 | 上部 |
| 精検受診率 | 70％以上 | 下部 |
| がん発見率 | 0.13％以上 | 下部 |

精度管理指標の場合，要精検率は高すぎるのは問題であるし，精検受診率は逆に高いほどよい（低すぎるのは問題である）。大腸がん検診における精度管理指標の許容値およびFunnel plotにおける逸脱域（高すぎると問題であれば上部，低すぎると問題であれば下部）を表1に示した。

## Ⅲ 結　　果

がん検診の精度管理指標のうち，要精検率，精検受診率，がん発見率における各許容値を基準としたFunnel plotを男女別に，集団方式（図2），個別方式（図3）別にそれぞれ示した。また，全体，集団方式，個別方式別でみた要精検率，精検受診率，がん発見率のうち，どれか一つでも統計的に有意（p＜0.05）に逸脱していた市町村について，各指標値を一覧表にした（表2）。

全体では男性で特に要精検率の高い市町村が多く，43市町村中21が許容値と比べて統計的に有意に高い要精検率を示した。精検受診率は男女とも低い市町村が多く，男性では12，女性では13の市町村で許容値の70％よりも統計的に有意に低い値を示した。要精検率は集団方式と比べて個別方式の方が高く，集団方式では統計的に有意に高い値を示したのは男性で40市町村中4つのみであったが，個別方式では26の市町村のうち，20市町村であった。一方，精検受診率は個別方式でばらつきが大きく（各市町村の値の標準偏差，男性：19.4，女性：15.8），許容値と比べて統計的に有意に低い市町村が多かった（男性で13/26市町村，女性で14/26市町村）。集団方式では個別方式よりもばらつきがやや小さく（各市町村の値の標準偏差，男性：13.4，女性：12.5），高い精検受診率を示した市町村が多かった。がん発見率にはあまり大きな特徴の違いがみられなかった。

図2　平成20年度大阪府大腸がん検診精度管理指標：75歳未満，集団方式

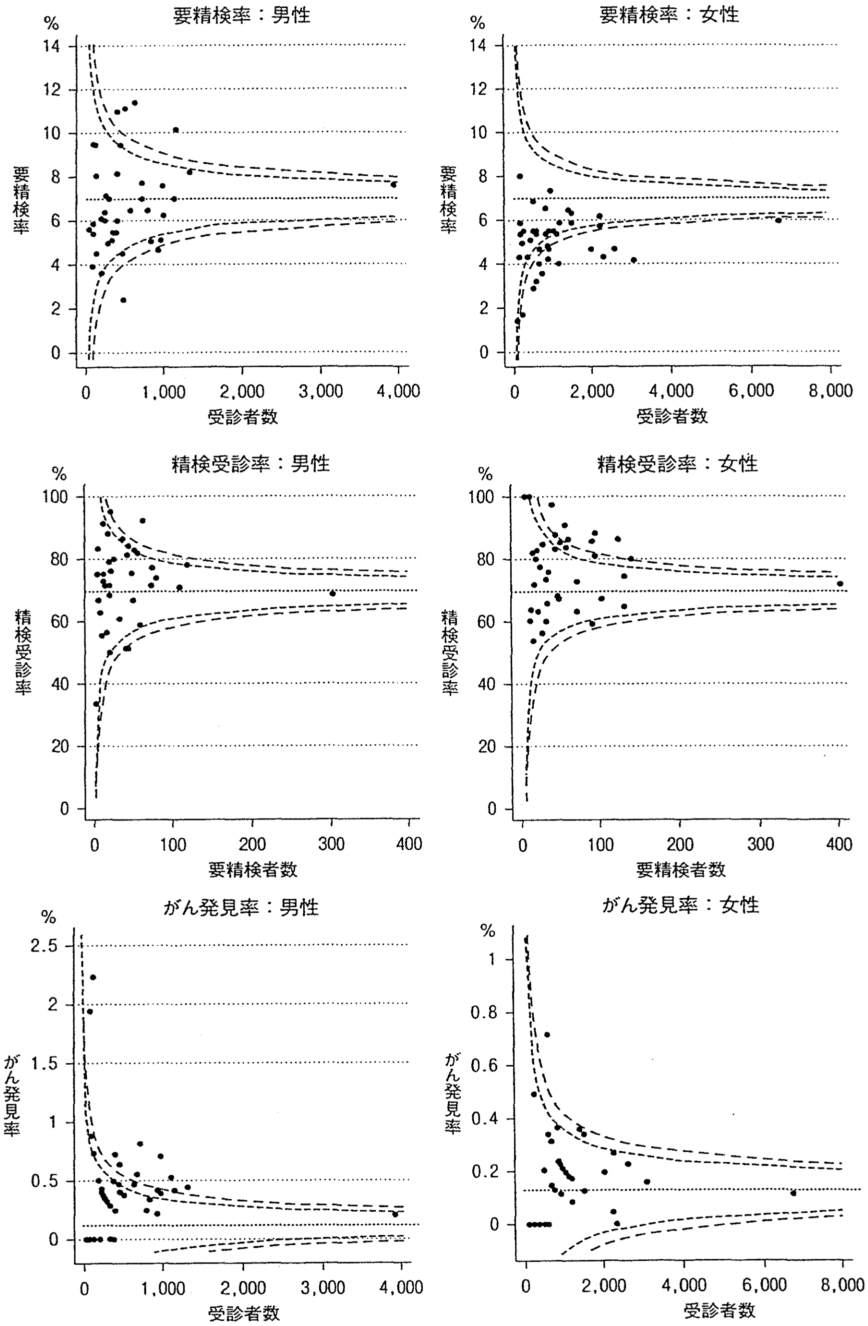
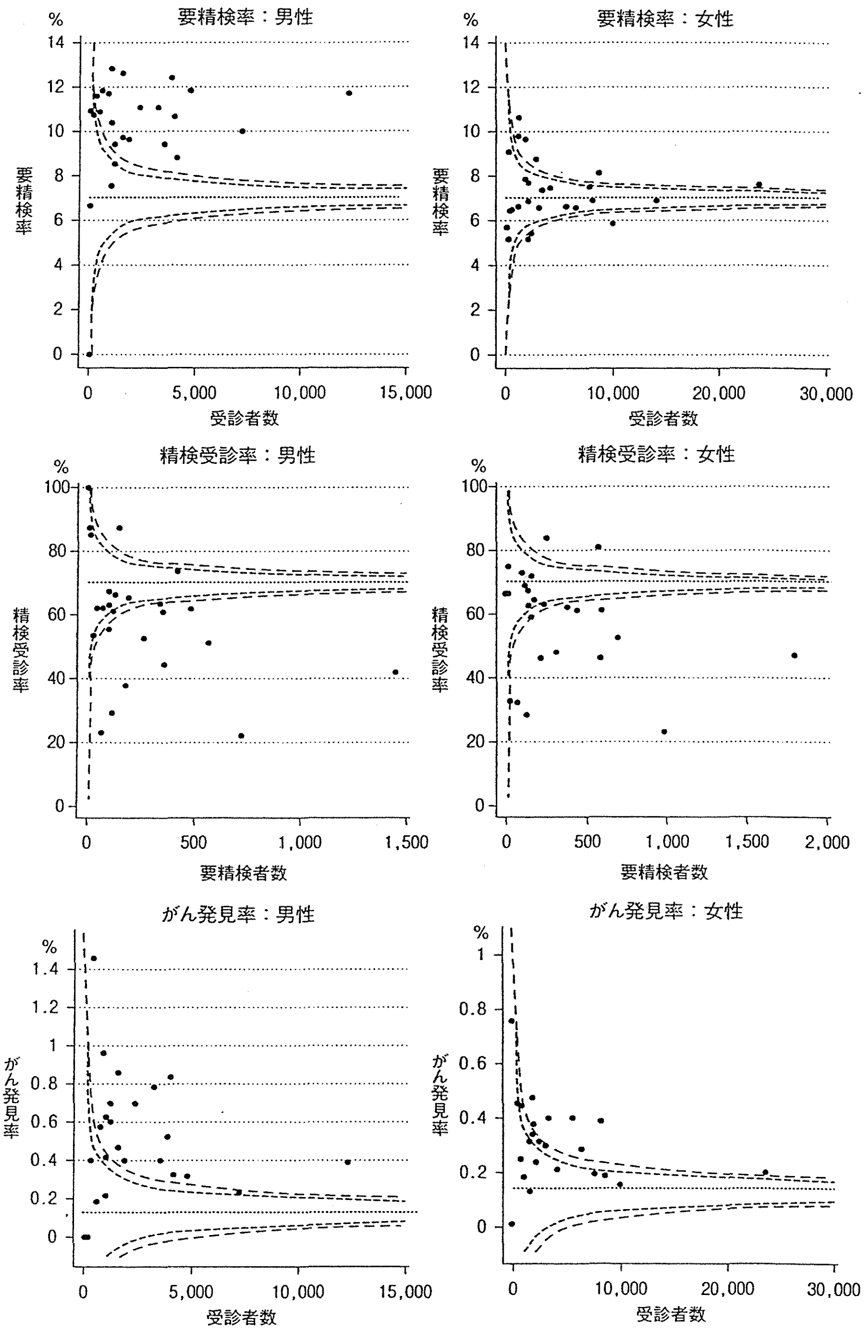


図3　平成20年度大阪府大腸がん検診精度管理指標：75歳未満，個別方式




## Ⅳ 考　　察

Funnel plotを用いて，大阪府における市町村の大腸がん検診精度管理指標を性別，集団／個別方式別に評価した。市町村間の人口のばらつきを考慮し，目標とする値（目標値あるいは許容値）と比べて，統計的に有意に高い（あるいは低い）かどうかを検討することで，検診が正しく実施されているかを評価することが可能であることが示唆された。

大阪府の市町村における大腸がん検診の精度管理指標を評価した上で，抽出された問題点は，個別方式において要精検率が高く，精検受診率が低いことがあげられる。個別方式の大腸がん検診において要精検率が高い理由としては，「有症状者への検診の適用」や「感度が高く，特異度の低い診療用の検査キットの検診への転用」などの可能性が考えられる。また，精検受診率が低かったのは，個別方式において，「要精検者に対し，便潜血の再検査を実施し，精検を行っていない」など精検の受診勧奨が不十分であると考えられた。精検受診率のばらつきが個別方式で大きく，集団方式で小さく，全体としては個別方式が低い値を示したのは，個別方式の検診実施医療機関と集団方式の委託検診機関の精検受診勧奨および結果把握への取り組みの違いに起因すると考えられる。大阪府における大腸がん検診の約60％を担う，個別方式における精検受診率の向上が，全体の底上げにおいて重要な課題であることが示唆された。今回用いた「大阪府におけるがん検診」に収載されている大腸がん検診の精検結果の把握方法についての独自調査によると，集団方式において，高い精検受診率を達成している市町村では，委託医療機関における要精検者の管理や結果把握および情報共有が徹底して行われていた。また，精検未受診者への連絡を手紙および電話で行い，不通の場合は再度連絡・指導しているところが多かった。各市町村の担当者からの聞き取りや研修会

等での情報収集によると，個別方式において高い精検受診率を達成している市では，年に２回，市医師会との連絡協議会を行うなどの工夫がなされていることがわかった。一方，個別方式の精検受診率が特に低い市町村は，人口規模の大きい市が多く，要精検者の追跡が不十分であったり，精検未受診者への再勧奨を個々の医療機関に任せて市町村は関与しなかったりするなど，要精検者の追跡や受診勧奨を十分に行っていないことがわかった。これらのことにより，がん検診の精度管理で重要なことは精検受診率を上げるための取り組みを委託検診機関と市町村がともに協働して行う体制構築が重要であることが改めて示唆され，このような体制を各市町村に広めていく必要がある。

表２　大腸がん検診の精度管理指標において，一つでも統計的に有意に許容値を逸脱した市町村一覧

| | 全体 | | | 集団 | | | 個別 | | |
|---|---|---|---|---|---|---|---|---|---|
| | 要精検率 | 精検受診率 | がん発見率 | 要精検率 | 精検受診率 | がん発見率 | 要精検率 | 精検受診率 | がん発見率 |
| 男性 | | | | | | | | | |
| 大阪市 | 10.8** | 47.1** | 0.352 | 7.7 | 69.3 | 0.228 | 11.8** | 42.5** | 0.392 |
| 豊中市 | 9.1** | 46.3** | 0.328 | 11.2** | 58.6 | 0.385 | 8.8** | 44.3** | 0.320 |
| 池田市 | 10.3** | 55.6** | 0.190 | 9.5 | 55.6 | 0.000 | 10.3** | 55.6** | 0.209 |
| 吹田市 | 9.7** | 74.3 | 0.749 | 5.1 | 81.4 | 0.353 | 10.7** | 73.6 | 0.834 |
| 箕面市 | 10.1** | 58.0** | 0.603 | 8.2 | 70.9 | 0.448 | 11.1** | 52.5** | 0.694 |
| 高槻市 | 9.7** | 62.8** | 0.702 | 5.1 | 75.5 | 0.416 | 11.1** | 61.0** | 0.788 |
| 茨木市 | 8.8** | 66.4 | 0.369 | 6.5 | 83.0 | 0.244 | 9.4** | 63.7* | 0.397 |
| 摂津市 | 4.6 | 51.2** | 0.213 | 4.6 | 51.2** | 0.213 | - | - | - |
| 守口市 | 10.1** | 78.2 | 0.426 | 10.1** | 78.2 | 0.426 | - | - | - |
| 枚方市 | 12.3** | 63.6** | 0.516 | 11.0** | 84.4 | 0.488 | 12.5** | 61.7** | 0.519 |
| 大東市 | 12.0** | 66.2 | 0.649 | 5.4 | 66.7 | 0.893 | 12.8** | 66.1 | 0.620 |
| 門真市 | 8.9** | 64.5 | 0.590 | 6.1 | 91.7 | 0.508 | 9.4** | 61.5 | 0.604 |
| 四條畷市 | 10.9** | 59.5 | 0.260 | 9.4 | 75.0 | 0.000 | 11.6** | 53.3* | 0.388 |
| 交野市 | 10.8** | 34.0** | 0.305 | 9.4 | 51.2** | 0.458 | 11.9** | 23.1** | 0.183 |
| 八尾市 | 10.2** | 81.9 | 0.739 | 11.4** | 71.6 | 0.463 | 9.7** | 87.1 | 0.857 |
| 東大阪市 | 11.9** | 51.2** | 0.316 | - | - | - | 11.9** | 51.2** | 0.316 |
| 河内長野市 | 8.9** | 41.4** | 0.373 | 5.4 | 68.4 | 0.285 | 9.6** | 38.4** | 0.390 |
| 松原市 | 9.1** | 68.9 | 0.843 | 4.5 | 76.2 | 0.640 | 11.7** | 67.3 | 0.957 |
| 大阪狭山市 | 10.9** | 62.2 | 1.453 | - | - | - | 10.9** | 62.2 | 1.453 |
| 堺市 | 9.9** | 23.2** | 0.242 | 6.3 | 56.3 | 0.397 | 10.0** | 22.5** | 0.237 |
| 岸和田市 | 10.2** | 67.8 | 0.492 | 7.0 | 73.8 | 0.526 | 12.6** | 65.3 | 0.466 |
| 泉南市 | 13.2** | 36.7** | 0.514 | 7.1 | 78.9 | 0.375 | 15.5** | 29.4** | 0.567 |
| 女性 | | | | | | | | | |
| 大阪市 | 7.2 | 52.0** | 0.175 | 6.0 | 72.0 | 0.119 | 7.5** | 47.5** | 0.190 |
| 豊中市 | 6.0 | 48.7** | 0.149 | 7.4 | 63.4 | 0.207 | 5.8 | 46.9** | 0.143 |
| 池田市 | 9.3** | 64.5 | 0.275 | 5.8 | 60.0 | 0.000 | 9.7** | 64.8 | 0.304 |
| 箕面市 | 6.8 | 53.4** | 0.225 | 5.7 | 64.8 | 0.269 | 7.4 | 48.5** | 0.201 |
| 高槻市 | 6.0 | 68.6 | 0.343 | 4.7 | 86.1 | 0.232 | 6.6 | 62.8** | 0.395 |
| 茨木市 | 6.3 | 63.6** | 0.272 | 4.6 | 83.3 | 0.219 | 6.5 | 61.6** | 0.280 |
| 枚方市 | 7.4 | 63.3** | 0.189 | 6.6 | 83.6 | 0.239 | 7.5 | 61.3** | 0.184 |
| 門真市 | 6.6 | 59.9** | 0.378 | 5.5 | 56.0 | 0.000 | 6.9 | 60.6* | 0.468 |
| 四條畷市 | 6.0 | 60.0 | 0.298 | 5.0 | 81.8 | 0.000 | 6.4 | 51.7* | 0.444 |
| 交野市 | 6.0 | 48.5** | 0.301 | 5.4 | 68.2 | 0.367 | 6.5 | 32.7** | 0.238 |
| 東大阪市 | 8.1** | 53.1** | 0.177 | - | - | - | 8.1** | 53.1** | 0.177 |
| 河内長野市 | 6.2 | 53.3** | 0.276 | 4.8 | 87.8 | 0.236 | 6.5 | 46.3** | 0.287 |
| 羽曳野市 | 5.9 | 59.1* | 0.134 | 5.9 | 59.1* | 0.134 | - | - | - |
| 大阪狭山市 | 9.8** | 73.3 | 0.437 | - | - | - | 9.8** | 73.3 | 0.437 |
| 堺市 | 6.8 | 24.7** | 0.056* | 2.8 | 71.4 | 0.000 | 6.9 | 24.0** | 0.058* |
| 岸和田市 | 6.7 | 64.8* | 0.161 | 4.4 | 67.3 | 0.000 | 8.7** | 63.6* | 0.302 |
| 泉南市 | 9.5** | 39.1** | 0.189 | 6.9 | 75.8 | 0.208 | 10.6** | 28.8** | 0.181 |

注　**p <0.01，*p <0.05

Funnel plotを用いて，人口規模を考慮した評価が可能であるが，ごく小規模の市町村に関しては，信頼区間が広くなるため，常にFunnel plotの曲線内に位置づけされるため，数年束ねた分析を併せて行うなどの工夫が必要である。また，Funnel plotは図表描画ソフトがあれば，容易に描くことが可能であるが，より汎用性の高いツールの開発が求められる。

本研究では大阪府が独自に収集し，発行しているがん検診の精度管理指標の報告を用いたが，厚生労働省によりWebで公開されている「地域保健・健康増進事業報告」[8]の資料を用いて，各都道府県でも実施が可能である。各都道府県に設置された生活習慣病管理指導協議会において，市町村におけるがん検診事業が適正に実施されているかを評価する上でも，重要な資料となり得るだろう。

今回の検討では一つ一つのがん検診精度管理指標についての検討であったが，Funnel plotをもとに極端な値を示す市町村を発見するだけでなく，これらの情報を統合し，各市町村のがん検診実施における多面的な評価を行うことで，事業全体の改善につながると考えられる。今後は各市町村担当者が実施体制の向上に活用できるように，ホームページ等での公表方式なども検討していく。

## Ⅴ 結　　語

Funnel plotを用いた市町村におけるがん検診精度管理指標の評価は，人口規模を考慮した上で，目標値を基準とした統計的な評価が可能であることがわかった。定量的な評価を行うとともに，高い成果を上げている市町村の実施体制を広めることで，全体の精度管理実施体制を強化していく必要性が示唆された。

謝辞

本研究は厚生労働科学研究費補助金（がん臨床研究事業）「既存統計資料に基づくがん対策進捗の評価手法の研究」班（研究代表者：津熊秀明）および厚生労働科学研究費補助金（第３次対がん総合戦略研究事業）「標準的検診法と精度管理に係る新たなシステムなどの開発に関する研究」班（研究代表者：斎藤博）において実施された。統計資料の提供をしていただいた（財）大阪がん予防検診センター調査室（当時）の皆様に深く御礼申し上げます。

注　誌面の都合上省略した大腸がん以外の，胃がん，肺がん，乳がん，子宮頸がん検診に関しての結果は，上記研究班の平成23年度報告書に掲載されている（http://www.mc.pref.osaka.jp/ocr/gaiyo/text/ito_h23_tsukumahan.pdf）。

## 文　　献

１）がん予防重点健康教育及びがん検診実施のための指針（平成10年３月厚生労働省老人保健課長通知）（http://www.mhlw.go.jp/bunya/kenkou/dl/gan_kenshin02.pdf）2013.2.27.

２）「今後の我が国におけるがん検診事業評価の在り方について」報告書（http://www.mhlw.go.jp/shingi/2008/03/s0301-4.html）2012.6.11.

３）大阪府健康医療部，大阪がん予防検診センター．大阪府におけるがん検診　平成20年度（2008年度）．2011.

４）Spiegelhalter DJ. Funnel plots for com paring institutional performance. Stat Med 2005；24(８)：1185-202.

５）Ito Y, Ioka A, Tsukuma H, et al. Regional differences in population-based cancer survival between six prefectures in Japan：Application of relative survival models with funnel plots. Cancer Sci 2009；100(７)：1306-11.

６）Coleman MP, Quaresma M, Berrino F, et al. Cancer survival in five continents：a worldwide population-based study（CONCORD). Lancet Oncol 2008；9(８)：730-56.

７）Quaresma M, Coleman MP, Rachet B. Funnel plots for population-based cancer survival：principles, methods and applications. Statistics in Medicine 2013；(in press).

８）地域保健・健康増進事業報告（http://www.mhlw.go.jp/toukei/list/32-19_h22.html）2012.10.15.

uicc
global cancer control

IJC
International Journal of Cancer

# 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

Takahiro Tabuchi[1], Takahiro Hoshino[2], Tomio Nakayama[1], Yuri Ito[1], Akiko Ioka[1], Isao Miyashiro[1] and Hideaki Tsukuma[1]

[1] Center for Cancer Control and Statistics, Osaka Medical Center for Cancer and Cardiovascular Diseases, Osaka, Japan
[2] Graduate School of Economics, Nagoya University, Aichi, Japan

**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
Additional Supporting Information is available in the Web site of Int. J. Cancer. (http://onlinelibrary.wiley.com/journal/)
**Conflict of interest:** The authors have declared no conflicts of interest.
**Grant sponsor:** Japanese Ministry of Health, Labour and Welfare; **Grant number:** H23-ganrinsho-011; **Grant sponsor:** Osaka Prevention Center for Cancer and Cardiovascular Diseases; **Grant number:** H23-03
**DOI:** 10.1002/ijc.28095
**History:** Received 7 Sep 2012; Accepted 28 Jan 2013; Online 7 Feb 2013
**Correspondence to:** Takahiro Tabuchi, Center for Cancer Control and Statistics, Osaka Medical Center for Cancer and Cardiovascular Diseases, 3-3, Nakamichi 1-chome, Higashinari-ku, Osaka 537-8511, Japan. Tel.: +81-6-6972-1181, Fax: +81-6-6981-3014, E-mail: tabuti-ta@mc.pref.osaka.jp

**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

Epidemiology

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 |

Epidemiology

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

| | Cervical cancer screening group | | | | Breast cancer screening group | | | |
|---|---|---|---|---|---|---|---|---|
| | 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 | 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%

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

| Characteristics | Cervical cancer screening group | | | | Breast cancer screening group | | | |
|---|---|---|---|---|---|---|---|---|
| | Cervical cancer screening attendance rates | | | | Breast cancer screening attendance rates | | | |
| | 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), % |
| **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

Epidemiology

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

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



Int. J. Cancer: 133, 972–983 (2013) © 2013 UICC

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.

## Acknowledgement

We thank Dr. A. Oshima and Dr. J. Mortimer for valuable comments. Institutional review board (IRB) approval was not sought because analyses of national survey data were considered to be exempt from the need for IRB review according to the Epidemiological Research Guidelines.

## References

1. American Cancer Society. Global cancer facts & figures, 2nd edn. Atlanta, GA: American Cancer Society, 2011.
2. Cancer Control Promotion Conference. Proceedings and reports. Tokyo, Japan: Ministry of Health, Labour and Welfare, 2011 (in Japanese).
3. von Karsa L, Anttila A, Ronco G, et al. Cancer screening in the European Union. Report on the implementation of the council recommendation on cancer screening—first reported. Luxembourg: the European Commission, 2008.
4. Ministry of Health, Labour and Welfare. Practice of the cancer screening in municipalities in 2010. Available at: http://www.mhlw.go.jp/stf/shingi/2r9852000002bifz.html (in Japanese).
5. OECD. OECD Health Data 2012. Available at: http://www.oecd.org/els/healthpoliciesanddata/oecdhealthdata2012.htm.
6. Anttila A, Ronco G, Clifford G, et al. Cervical cancer screening programmes and policies in 18 European countries. *Br J Cancer* 2004;91:935–41.
7. Baron RC, Rimer BK, Coates RJ, et al. Client-directed interventions to increase community access to breast, cervical, and colorectal cancer screening a systematic review. *Am J Prev Med* 2008;35:S56–S66.
8. Spadea T, Bellini S, Kunst A, et al. The impact of interventions to improve attendance in female cancer screening among lower socioeconomic groups: a review. *Prev Med* 2010;50:159–64.
9. Sabatino SA, Lawrence B, Elder R, et al. Effectiveness of interventions to increase screening for breast, cervical, and colorectal cancers: nine updated systematic reviews for the guide to community preventive services. *Am J Prev Med* 2012;43:97–118.
10. Everett T, Bryant A, Griffin MF, et al. Interventions targeted at women to encourage the uptake of cervical screening. *Cochrane Database Syst Rev* 2011;5:CD002834.
11. Mackenbach JP, Stirbu I, Roskam AJ, et al. Socioeconomic inequalities in health in 22 European countries. *N Engl J Med* 2008;358:2468–81.
12. World Health Organization. A conceptual framework for action on the social determinants of health. Geneva: WHO Document Production Services, 2010.
13. Fukuda Y, Nakamura K, Takano T. Reduced likelihood of cancer screening among women in urban areas and with low socio-economic status: a multilevel analysis in Japan. *Public Health* 2005;119:875–84.
14. Yabroff KR, Gordis L. Does stage at diagnosis influence the observed relationship between socioeconomic status and breast cancer incidence, case-fatality, and mortality? *Soc Sci Med* 2003;57:2265–79.