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► To cite this version:

Sébastien Dawidowicz, Julien Le Breton, Laura Moscovia, Vincent Renard, Sandrine Bercier, et al.. Predictive factors for non-participation or partial participation in breast, cervical and colorectal cancer screening programmes. *Family Practice*, 2020, 37 (1), pp.15-24. 10.1093/fampra/cmz031 . hal-03244263

HAL Id: hal-03244263

<https://hal.science/hal-03244263>

Submitted on 1 Jun 2021

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Article category : Epidemiology

Running title: cancer screening participation rates in women

Keywords: Cancer Care / Oncology ; Cancer, Breast ; Cancer, Cervical ; Cancer, Colorectal ; Primary Care ; Screening

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This work has been presented in part at the CNGE congress (November 2016, Grenoble, France).

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Keywords: cancer, screening, primary care, public health

Word count: 2901 (max: 3000)

KEY MESSAGES

- Only 11.5% of women participate in all three cancers screening
- Social deprivation is predictive of the 3 cancers screening non-participation
- More deprivation level affect more non-participation in cancer screening

ABSTRACT

BACKGROUND : No study has investigated factors associated with non-participation or partial participation in the different combination patterns of screening programmes for all three cancers i.e., breast, colorectal and cervical cancer.

METHODS : In a retrospective cohort study, we sought to describe combinations of cancer screening participation rates among women in the Val-de-Marne area of France, and to identify individual and contextual factors associated with non-participation or partial participation.

RESULTS : Women aged between 50 and 65 and who were eligible for all three screening programmes (n=102,219) were analyzed in multilevel logistic models, with the individual as the level 1 variable and the place of residence as the level 2 variable. The women who did not participate in any of the screening programmes were 34.4%, whereas 30.1%, 24%, and 11.5% participated in one, two or all three screening programmes, respectively. Age below 55, a previous false-positive mammography, prior opportunistic mammography only, no previous

mammography, membership of certain health insurance schemes (all $p < 0.05$), and residence in a deprived area ($p < 0.001$) were independently associated with non-participation or partial participation. We observed a stronger effect of deprivation on non-participation in all three cancers than in combinations of screening programmes.

CONCLUSION : Our findings suggest that the health authorities should focus on improving cancer screenings in general, rather than screenings for specific types of cancer, especially among younger women and those living in the most socially deprived areas.

INTRODUCTION

Breast cancer and colorectal cancer (CRC) are the most incident cancers among women, and respectively account for first and third leading causes of cancer death¹. Cervical cancer is ranked fourth in terms of incidence and cancer-related deaths among women worldwide¹.

Screening programmes for these cancers among women (mammography, faecal occult blood testing (FOBT) and Pap testing) have been extensively studied²⁻⁴. The latest European guidelines recommend that participation rates of at least 70%, 50% and 80% are needed to obtain significant decreases in mortality rates for breast cancer, cervical cancer and CRC, respectively⁵⁻⁷. The French health authorities launched nationwide, free-of-charge, organized screening (OS) programmes for breast cancer in 2004 and for CRC in 2009. Around 10% of French women undergo opportunistic screening (OpS), i.e. individually prescribed mammography⁸. Although French cervical cancer screening was opportunistic until 2018, a pilot OS programme (restricted to non-up-to-date women) was launched in 13 French counties in 2010. From 2010 to 2012, nationwide participation rates in these programmes for women were lower than expected (52% (only OS), 34%, and 62% for breast cancer, CRC, and cervical cancer, respectively)⁹⁻¹¹.

The French screening programmes for these cancers target women between the ages of 50 and 65. Low individual socioeconomic status, residence in a deprived area, poor access to healthcare, smoking, disability, and previous non-participation in cancer screening programmes were associated with non-participation in breast cancer, CRC, and cervical cancer screening, and assessed in isolation from one another¹²⁻¹⁷. Other factors linked to non-participation included very old age for breast cancer screening, younger age for CRC screening, and older age for cervical cancer screening^{18,19}. Factors associated with non-participation in combinations of screening programmes have only been studied for breast and cervical cancers; the significant factors were older age, poor socioeconomic status, active smoking, and residence in a rural area²⁰. However, to date no study has investigated factors associated with non-participation or partial participation in the different combination patterns

of screening programmes for all three cancers (i.e. participation in a single programme, two programmes, or all three programmes).

The primary objective of the present study was to describe patterns and rates of non-participation or partial participation in combinations of screening programmes for all three cancers by French women aged 50 to 65 years. The secondary objective was to investigate individual and contextual factors associated with non-participation or partial participation. We hypothesized that age, poor access to healthcare, and social deprivation were associated with low screening rates, and that a gradient would be observed across the combinations (e.g. social deprivation would be more strongly linked to non-participation than to participation in one, two or three screening programmes).

MATERIALS AND METHODS

Setting

This retrospective cohort study was conducted in the Val-de-Marne county – part of the greater Paris urban area with a population of 1.3 million (accounting for 2% of the French population). This area launched screening campaigns for breast cancer in 2004, for CRC in 2007, and for cervical cancer in 2010.

Cancer screening programmes for women

The Val-de-Marne cancer screening centre (*Association de dépistage organisé des cancers dans le Val-de-Marne* (ADOC94)) sent a letter offering free-of-charge mammographic screening to all female residents aged between 50 and 74. Women who had not replied 6 months later were sent a reminder. The data on breast cancer screening (including previous screening visits) were based on the women's replies (for OpS) and/or the case report form for participation in OS programmes. Likewise, all women aged 50-74 were invited to participate in CRC screening and to collect a free FOBT kit from their GP. Women who had not replied 6 months later were sent a reminder letter. Up until 2015, women who had not replied to the first reminder were sent a second letter and an FOBT kit. For cervical cancer screening,

women aged 25-65 and who had not undergone a documented Pap test in the previous three years were invited by post to arrange a screening visit with their GP, gynaecologist, midwife or local medical laboratory. Women who had not replied 12 months later were sent a reminder.

Data sources

Data on individual predictors were directly extracted in January 2016 from the ADOC94 database such as the women's individual factors, participation in screening programmes, and GPs information. Those informations were collected from women, radiologist centres, physicians and for Pap test status, from the national health insurance database. The study database was registered with the French National Data Protection Commission (CNIL; reference: 187584). Data on contextual predictors (i.e. area of residence characteristics) were obtained from the French National Institute of Statistics and Economic Studies (INSEE) database.

Study population

The main inclusion criteria were (i) age between 50 and 65, (ii) eligibility for all three screening programmes, (iii) residence in the study area, and (iv) invitation for breast cancer and CRC screenings between November 2010 and October 2012. To avoid major selection bias, we did not include all women invited to attend a cervical cancer OS programme in the Val de Marne area, since only women lacking up-to-date Pap testing would have been included (n=68,936, 67.4% of the eligible population) (Figure 1).

Outcomes

Participation was quantified as the combined OS + OpS rate. The primary outcome (levels of participation in one to three screening programmes) was classified into four modalities: non-participation (coded as "NP"), participation in one of the three programmes ("P1"), participation in two of the three programmes ("P2"), and full participation ("FP"). Participation in breast cancer and CRC screening programmes was defined as participation

within 2 years of receipt of the initial invitation sent during November 2010 and October 2012. Participation in the cervical cancer screening programme was defined as participation within 3 years of having been invited to attend one of the other screening programmes.

Potential predictors

The putative individual predictors of non-participation or partial participation (studied at level 1) included age at the time of the first invitation (for breast cancer and CRC screening) and membership of various special statutory health insurance schemes (e.g. schemes for employees, farmers and agricultural workers, self-employed people, civil servants, etc.). We created a four-category variable for mammography: no previous mammography (in either OS or OpS programmes); mammography in an OpS programme; a normal mammography in an OS programme; and a false-positive mammography finding in an OS programme (including non-malignant breast tumors) (Table 3). We also extracted the following predictors: previous screening for CRC and cervical cancer; screening rank (the number of visits to breast cancer and CRC screening programmes, including the current programme; this information was not available for cervical cancer screening); receipt of a first reminder for CRC and breast cancer screening (after 6 months) or for cervical cancer screening (after 12 months); and receipt of a second reminder and an FOBT kit.

Area of residence (according to the latest French census data) was studied at level 2. In relation to this level, the following contextual factors were analyzed: socioeconomic status (quintiles of the European Deprivation Index (Pornet et al, 2013)), and healthcare access by the median number of GP's per 100,000 people (in tertiles), and the local presence of a gynaecologist, gastroenterologist, radiologist, midwife and/or health centre²¹.

Statistical analysis

We assessed the distributions of the different combinations of NP, P1 and P2 (with FP as the reference category), and applied random-intercept multilevel logistic models with individuals (level 1) nested into areas (level 2). Univariable analyses were performed with the chi-square test for categorical variables and the Kruskal-Wallis test for continuous variables. Variables

with $p < 0.2$ were selected for multivariable analysis. Confounders and interactions were tested in bivariate models. To avoid introducing highly correlated variables into the models (e.g. previous mammography in an OS programme and screening rank for breast cancer OS; previous FOBT, previous mammography, and previous Pap test), only the most relevant variables (according to the Bayesian information criterion) were included in the multivariable models. We first used an empty multilevel logistic model to estimate whether significant clustering (assessed with the intra-class correlation coefficient (ICC)) occurred within areas of residence for NP or P1 or P2 ²². Next, we included the level 1 and level 2 predictors, and assessed the extent to which area patterns affected the probability of patient participation. We computed the ICCs and thus estimated the proportion of total variance in the participation rate that was attributable to inter-areas. We also estimated the proportion of between-group variability related to the contextual factors at the group level, after the inclusion of level 1 and level 2 variables ²³.

All tests were two-sided, and the threshold for statistical significance was $p \leq 0.05$. Subgroup comparisons were corrected for multiple comparisons using Bonferroni's method. (threshold: $p < 0.008$). All statistical analyses were performed with Stata software (StataCorp, College Station, TX, USA).

RESULTS

Study population

A total of the 102,219 women were analysed (Table 1). The median [interquartile range (IQR)] age at the time of the first screening invitation (breast cancer or CRC) was 55.7 [51.9-59.7]. The screening rates for breast cancer, CRC and cervical cancer were respectively 44.6% (including 3.6% in OpS programmes), 24.7% (all in OS) and 43.3% (Table 2). The NP group comprised 35,159 women (34.4%), with 30,800 women (30.1%) in P1, 24,510 women (24.0%) in P2 and 11,750 women (11.5%) in FP.

Factors associated with non-participation/partial participation

Significant individual and contextual predictors, associated with non-participation or partial participation are mentioned in table 3.

Given the strong correlation between non-participation and previous mammography status (Table 4), the latter was not included in the multivariable model of non-participation. The multilevel multivariable analysis evidenced significant variability from one area of residence to another ($p < 0.001$). The following factors were associated with non-participation: younger age, self-employment, agricultural occupation, membership of special health insurance schemes in large companies, and residence in deprived areas. The same factors were associated with partial participation as well as a history of false-positive mammography findings in OS programmes, mammography in OpS programmes only, and no previous mammography.

The non-participation and partial participation rates varied significantly from one area of residence to another (from 2.1% to 0.4%, in the empty models). After adjustment, 1%, 0.6% and 0.3% of the total variability were explained by inter-area differences in NP, P1 and P2, respectively (Table 4). Socioeconomic status (the European Deprivation Index) accounted for 47%, 39.9% and 12.5% of the inter-area variability in NP, P1 and P2, respectively. Lastly, we observed a gradient in ORs for the most deprived area and self-employment for the NP, P1 and P2 groups; these factors had a stronger negative effect for NP than they did for P1 and P2.

Subgroup analyses

Compared with the FP group, the absence of previous mammography was strongly associated with P1 women who did not participate in CRC or breast cancer screening but had participated in cervical cancer screening (online supplement Table S1). Older age, residence in deprived areas, and the absence of mammography in OpS programmes were associated with P2 women who did not participate in cervical cancer screening but had participated in both breast and CRC screening programmes, relative to other combinations (online supplement Table S2).

DISCUSSION

We found that only 11.5% of the study population participated in all three screening programmes. Overall, 24% of the women participated in two programmes (13.7% for breast cancer + cervical cancer, 6.3% for CRC + breast cancer, and 4% for cervical cancer + CRC), and 30.1% participated in one programme (13.1% for breast cancer, 14.1% for cervical cancer, and 2.9% for CRC). The non-participation rate was 34.4%. When compared with participation in all three screening programmes, the factors linked to non-participation or partial participation were young age, membership of certain health insurance schemes, a previous false-positive mammography in an OS programme, previous mammography in an OpS programme only, no previous mammogram (in OS or OpS programmes), and residence in the most deprived areas. Social deprivation was strongly associated with non-participation in general and non-participation in cervical cancer screening.

Strengths and limitations

The present study is the first to have investigated individual and contextual factors associated with non-participation or partial participation in breast cancer, cervical cancer and CRC screening among women aged 50-65. We focused on screening rates in general (rather than participation in OS programmes only) because they better reflect attitudes toward prevention. Furthermore, we used multilevel models because they are more appropriate for hierarchical data. However, data on breast cancer OpS programmes depends on women replying to the invitation, and so we may have underestimated this frequency. A substantial proportion of women classified as non-participants may have been screened in OpS programmes. The use of aggregate data for deprivation avoids declarative bias in survey studies but prevents one from drawing conclusions about individuals. Lastly, health professional density is not the best way to measure access to healthcare because it does not reflect geographical accessibility ²⁴.

Comparison with previous literature

Our OS rates for breast cancer (44.6%) and CRC (24.7%) were similar those reported for women aged 50-74 in the Val-de-Marne district in 2011-2012 (43.4% and 29.2%) respectively)^{9,10}. However, the breast cancer OpS rate (3.6%) was lower than the French national value (10%)^{8,25}. This difference might due to the low response rate to postal invitations in the breast cancer OS programme. The cervical cancer screening rate (OS+OpS) of 43.3% was participants attended all three cancer screening programme. We did not find any comparative literature data on FP rates. In line with the literature, the lowest participation rate was observed for CRC screening¹⁰.

As in other studies, age <55 was associated with non-participation in breast cancer and CRC screening^{26,28,29}. Older age has been linked with non-participation in cervical cancer screening^{26,27}. Self-employed status was previously found to be associated with non-participation in breast cancer screening¹⁹. These women's professional constraints may limit their availability for screening³⁰. As reported previously, residence in the most deprived areas was associated with non-participation or only partial participation in the three cancer screening programmes^{12,14}. The association effect was stronger for non-participation and participate in cervical cancer screening only.

We found a previous false-positive mammography findings were associated with non-participation or partial participation - particularly for cervical cancer screening. Other studies have reported that these mammography findings decrease subsequent participation in mammography screening^{31,32}. Previous mammography in an OpS programme only was strongly associated with non-participation or partial participation - especially for participation in cervical cancer screening but not in CRC and breast cancer screening. We hypothesize that many of these women are being followed up by gynaecologists. Gynaecological follow-up in France is reported to be associated with higher participation in cervical cancer screening and breast cancer OpS than in breast cancer OS²⁰. Moreover, gynaecologists may not systematically promote participation in OS for both CRC and breast cancer.

The absence of a previous mammography was associated with non-participation in all three screening programmes, in the breast cancer and CRC screening programme. Some studies have highlighted an association between previous mammography and subsequent mammography, Pap testing ¹⁴ and FOBT use ²⁰. This might also reflect a "mass screening" effect: a woman participating in one OS programme is more likely to participate in other OS programmes.

Lastly, many women (particularly the most economically deprived) do not have an sufficiently prevention-focused attitude to cancer screening - probably because of other priorities ^{33,34} and/or a lower educational level ²⁰. We suggest that some following interventions might improve full participation in cancer screening programmes. First, media campaigns and public health programmes for women should focus on cancer screening in general, and should adjust the level and type of information to suit the target population's socioeconomic level ³⁵. This corresponds to proportionate universalism, in which the intensity is proportional to the degree of need ³⁶.

Then, a national cervical cancer screening campaign (launched in France in 2018) might improve screening rates for both cervical cancer and other cancers ^{37,38}. And, for breast cancer, physicians should encourage women to participate in OS programmes rather than OpS programmes. Physicians should also suggest CRC screening when they inform women about screening programmes for gynaecological cancer ³⁹. Moreover, GPs have a central role in the general approach to prevention ³⁶. Initial and continuing medical education should focus on a broad-based approach to cancer screening (rather screening for just one type of cancer) and should include the concept of patient-centred care. As key stakeholders in public health, GPs maybe able to remove certain individual barriers and thus increase screening rates ⁴⁰⁻⁴³.

Conclusions

A small proportion of women (11.5%) participated in all three screening programmes (i.e. breast cancer, CRC and cervical cancer screening). Age <55, a previous false-positive

mammography, previous mammography in OpS programmes only, no previous mammography, residence in a deprived area, and membership of certain health insurance schemes were predictive of non-participation or partial participation in combination of screening programmes for all three cancers. We observed a stronger effect of deprivation on non-participation than on participation in combinations of screening programmes. Our findings highlight the need to target women aged 50 to 65 years and promote better overall participation in cancer screening programmes - especially among younger women and those living in highly deprived areas. Gynaecologists and GPs have a central role in informing women about screening programmes and improving screening rates.

CONFLICT OF INTEREST

None

FUNDING

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

ACKNOWLEDGEMENTS

We thank Frederic Grezis (Epiconcept, Paris, France) for assistance with data management and David Fraser and Laura Smales, for revising the manuscript.

We thank Ludivine Launais and Carole Pornet for the transmission of EDI through the national methodological platform for the Study and Reduction of Social Inequalities in Oncology (ERISC platform, INSERM Unit IU1086 "Cancers & Prevention").

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Table 1: Individual characteristics (level 1) and contextual characteristics (level 2) of the study population (2010-2015)**Individual characteristics (n=102,219)**

Age at the time of the initial invitation for breast or colorectal cancer screening (years): median [IQR]	55.7 [51.9-59.7]
Age group (years)	
50-54	46,765 (45.8%)
55-59	31,105 (30.4%)
60-64	24,349 (23.8%)
Statutory healthcare insurance scheme	
Salaried workers	78,831 (77.1%)
Civil servants	13,812 (13.5%)
Agricultural occupations	463 (0.5%)
Self-employed workers	4,127 (4.0%)
Large public-sector companies with special schemes	4,986 (4.9%)
Breast cancer screening	
At least 1 previous mammography in an OS programme	44,141 (43.2%)
Abnormal mammography (false-positive) n = 44,141	3,861 (8.7%)
Previous mammography in OpS programmes only	4,428 (4.3%)
Screening rank ^a	
Rank 1	24,231 (23.7%)
Rank 2	15,578 (15.2%)
Rank 3	11,214 (11.0%)
Rank 4	9,221 (9.0%)
Rank ≥ 5	3,988 (3.9%)
Missing data	37,987 (37.2%)
Postal reminder sent 6 months after the initial invitation	65,452 (64.0%)
Colorectal cancer screening	
At least 1 previous FOBT	24,582 (24.0%)
Screening rank ^a	
Rank 1	19,178 (18.8%)
Rank 2	15,332 (15.0%)
Rank ≥ 3	2,954 (2.9%)
Missing data	64,755 (63.3%)
Postal reminder sent 6 months after the initial invitation	85,734 (83.9%)
A second reminder with a FOBT kit sent to the home 6 months after the first reminder	77,041 (75.4%)
Cervical cancer	
Pap test in the previous 3 years	28,187 (27.6%)
Invitation letter for the current screening programme	68,936 (67.4%)
Postal reminder sent 12 months after the initial invitation, n= 68,936 ^b	24,352 (35.3%)

Contextual characteristics**Socio-economic deprivation in the area of residence****N= 102,197^c**European Deprivation Index^e

Quintile 1 (least deprived)	21,445 (21%)
Quintile 2	21,164 (20.7%)
Quintile 3	20,372 (19.9%)
Quintile 4	19,947 (19.5%)
Quintile 5 (most deprived)	19,269 (18.9%)

Healthcare in the area	N= 97,711^d
General practitioner density per 100,000 of the population ^f	
Tertile 1 (lowest density)	29,288 (30%)
Tertile 2	35,818 (36.6%)
Tertile 3 (highest density)	32,583 (33.4%)
Presence of specialist physicians and healthcare professionals in the area	
Gynaecologist	13,915 (14.2%)
Gastroenterologist	8,599 (8.8%)
Radiologist	11,076 (11.3%)
Midwife	11,116 (11.4%)
Medical centre	9,142 (9.4%)

Categorical variables are quoted as the n (%), and continuous variables are quoted as the median [interquartile range (IQR)] or in quintiles. OS: organized screening; FOBT: faecal occult blood test.

Data extraction in January 2016. Invitation sent during November 2010 and October 2012.

a. The rank is defined as a woman's total number of screening visits (including the current programme) for each type of cancer; these data were not available for cervical cancer screening programmes.

b. Number of women invited to the current OS programme in the study period

c. Number of areas with available information = 525

d. Number of areas with available information = 505

e. The European Deprivation Index is based on 11 census variables, expressed as percentages (Non-home-owners, unemployed people, foreign nationals, non-car-owners, unskilled workers/farmers, households of more than 6 people, low educational level, and single-parent households). The EDI ranged from -12.3 to +23.6, and was categorised in quintiles (with quintile 1 representing the least deprived area and quintile 5 representing the most deprived areas).

f. General practitioner (GP) density was categorised in tertiles. Tertile 0: 0 GPs; tertile 1: 1-2 GPs; tertile 3: 3-16 GPs.

Table 2: Screening rates for breast, colorectal and cervical cancer, for each of the eight possible combinations

Type of cancer screening				N = 102,219
Breast	Colorectal	Cervical	Coverage % (N)	Total % (N)
+	+	+	11.5% (11,750)	Full participation: 11.5% (11,750)
+	+	-	6.3% (6,412)	Participation in 2 of the 3 screening programmes: 24.0% (24,510)
+	-	+	13.7% (14,002)	
-	+	+	4.0% (4,096)	
+	-	-	13.1% (13,400)	Participation in 1 of the 3 screening programmes: 30.1% (30,800)
-	+	-	2.9% (2,979)	
-	-	+	14.1% (14,421)	
-	-	-	34.4% (35,159)	Non-participation: 34.4% (35,159)

Data extraction in January 2016. Invitation sent during November 2010 and October 2012.

Table 3: Univariable analysis of factors associated with non-participation or partial participation in the three screening programmes (2010-2015)

	Non-participation (NP) N=35,159 (34.4%)	Participation in 1 screening programme (P1) N= 30,800 (30.1%)	Participation in 2 screening programmes (P2) N = 24,510 (24.0%)	Full participation (FP) N= 11,750 (11.5%)	P value ^a
Individual characteristics (level 1)					
Age at the time of the initial invitation for breast or CRC screening (years)					
Median [IQR]	55.8 [51.9-59.8]	55.3 [51.9-59.3]	55.8 [52.0-59.9]	56.2 [52.4-60.1]	<0.001
Age group					
50-54	15.7 (44.8%)	14,935 (48.5%)	11,129 (45.4%)	4,969 (42.3%)	<0.001
55-59	10,983 (31.2%)	9,001 (29.1%)	7,379 (30.1%)	3,742 (31.9%)	
60-64	8,444 (24.0%)	6,864 (22.3%)	6,002 (24.5%)	3,039 (25.9%)	
Statutory healthcare insurance scheme					
Salaried workers	26,594 (75.6%)	23,666 (76.8%)	19,162 (78.2%)	9,409 (80.1%)	< 0.001
Civil servants	4,539 (12.9%)	4,194 (13.6%)	3,445 (14.1%)	1,634 (13.9%)	
Agricultural occupations	199 (0.6%)	164 (0.5%)	75 (0.3%)	25 (0.2%)	
Self-employed workers	2,012 (5.7%)	1,271 (4.1%)	642 (2.6%)	202 (1.7%)	
Large companies	1,815 (5.2%)	1,505 (4.9%)	1,186 (4.8%)	480 (4.1%)	
Breast cancer screening					
Previous mammography status					
At least 1 previous normal mammography result in OS	7,634 (21.7%)	11,876 (38.6%)	13,139 (53.6%)	7,631 (64.9%)	< 0.001
At least 1 previous abnormal mammography (false-positive findings) in OS	843 (2.4%)	1,191 (3.9%)	1,215 (5.0%)	612 (5.2%)	
Previous mammography in OpS programmes only	537 (1.5%)	1,555 (5.1%)	1,772 (7.2%)	564 (4.8%)	
No previous mammography (OS or OpS)	26,145 (74.4%)	16,178 (2.4%)	8,384 (34.2%)	2,943 (25.1%)	
Screening rank n= 64,232 ^b					
Rank 1	6,405 (57.5%)	7,856 (38.6%)	6,998 (32.5%)	2,972 (26.6%)	<0.001
Rank 2	2,772 (24.9%)	5,210 (25.6%)	5,095 (23.6%)	2,501 (22.4%)	
Rank 3	1,252 (11.2%)	3,502 (17.2%)	4,117 (19.1%)	2,343 (21.0%)	
Rank 4	497 (4.5%)	2,632 (12.9%)	3,746 (17.4%)	2,346 (21.0%)	
Rank ≥ 5	215 (1.9%)	1,148 (5.6%)	1,601 (7.4%)	1,024 (9.2%)	
Postal reminder sent 6 months after the initial invitation	32,952 (93.7%)	20,263 (65.8%)	9,538 (38.9%)	2,699 (23.0%)	<0.001
Colorectal cancer screening					
Previous FOBT	2,207 (6.3%)	5,080 (16.5%)	9,224 (37.6%)	8,071 (68.7%)	< 0.001

Screening rank n=37,464 ^b					
Rank 1	2,528 (86.6%)	5,845 (70.7%)	7,123 (49.0%)	3,682 (31.3%)	< 0.001
Rank 2	348 (11.9%)	2,130 (25.8%)	6,207 (42.7%)	6,647 (56.6%)	
Rank ≥ 3	42 (1.5%)	292 (3.5%)	1,199 (8.5%)	1,421 (12.1%)	
Postal reminder sent 6 months after the initial invitation	33,551 (95.4%)	28,022 (91.1%)	18,502 (75.5%)	5,659 (48.2%)	< 0.001
A second reminder with a FOBT kit sent to the home 6 months after the first reminder	32,129 (91.4%)	26,477 (86.0%)	15,389 (62.8%)	3,046 (25.9%)	< 0.001
Cervical cancer screening					
Pap test in the previous 3 years	2,213 (6.3%)	9,150 (29.2%)	10,464 (42.7%)	6,360 (54.1%)	< 0.001
Invitation to OS	31,043 (88.3%)	20,077 (65.2%)	12,832 (52.4%)	4,984 (42.4%)	< 0.001
Postal reminder sent 12 months after the initial invitation n=68,936 ^c	12,678 (36.1%)	6,932 (22.5%)	3,657 (14.9%)	1,087 (9.3%)	< 0.001
Contextual characteristics (level 2)					
Level of area deprivation^d					
European deprivation index (n= 102,197) ^d					
Quintile 1 (least deprived)	6,352 (18.1%)	6,777 (22.0%)	5,516 (22.5%)	2,800 (22.2%)	< 0.001
Quintile 2	6,907 (19.7%)	6,564 (21.3%)	5,275 (21.5%)	2,418 (20.6%)	
Quintile 3	6,895 (19.6%)	6,177 (20.1%)	4,940 (20.2%)	2,360 (20.1%)	
Quintile 4	7,379 (21.0%)	5,757 (18.7%)	4,586 (18.7%)	2,225 (18.9%)	
Quintile 5 (most deprived)	7,615 (21.7%)	5,518 (17.9%)	4,189 (17.1%)	1,947 (16.6%)	
Healthcare in the area^e					
General practitioner density per 100,000 population (n= 97,711) ^e					
Tertile 1 (lowest density)	10,256 (30.3%)	8,715 (29.6%)	6,969 (29.9%)	3,348 (30.1%)	0.025
Tertile 2	12,538 (37.1%)	10,704 (36.4%)	8,532 (36.6%)	4,044 (36.3%)	
Tertile 3 (highest density)	11,029 (32.6%)	9,985 (34.0%)	7,823 (33.5%)	3,746 (33.6%)	
Presence of specialist physicians and healthcare professionals in the area					
Gynaecologist	4,600 (13.6%)	4,305 (14.6%)	3,385 (14.5%)	1,625 (14.6%)	< 0.001
Gastroenterologist	2,820 (8.3%)	2,671 (9.1%)	2,102 (9.0%)	1,006 (9.0%)	0.003
Radiologist	3,605 (10.7%)	3,444 (11.7%)	2,712 (11.6%)	1,315 (11.8%)	< 0.001
Midwife	3,684 (10.9%)	3,444 (11.7%)	2,712 (11.6%)	1,279 (11.5%)	0.006
Medical centre	3,234 (9.6%)	2,734 (9.3%)	2,183 (9.4%)	991 (8.9%)	0.21

Categorical variables are quoted as the n (%), and continuous variables are quoted as the median [interquartile range (IQR)] or in quintiles OS, organized screening;

OpS, opportunistic screening; FOBT, faecal occult blood test ; Data extraction in January 2016. Invitation sent during November 2010 and October 2012.

a. p-test from a chi-squared test; b. Number of women participating in at least one OS programme (including the OS in the study period); c. number of women invited

to the OS in the study period; d. Number of areas for which information was available = 525; e. Number of areas for which information was available = 505

Table 4. Multivariable multinomial logistic regression of factors associated with partial participation (P1 and P2) and non-participation (NP) in the three cancer screening programmes, with full participation (FP) as the reference category (n=11,750) (2010-2015)

Groups	Non-participation (NP) n=33,211 ^a		Participation in 1 screening programme (P1) n=30,793 ^b		Participation in 2 screening programmes (P2) n=24,506 ^c	
	aOR [95%CI]	p value ^d	aOR [95%CI]	p value ^d	aOR [95%CI]	p value ^d
Fixed effects						
Level 1: individual						
Age at the time of the initial invitation (years)						
50-54	Ref	<0.001	Ref	0.045	Ref	<0.001
55-59	0.94 [0.89-0.99]	<0.001*	0.93 [0.89-0.99]	<0.001*	0.90 [0.86-0.95]	<0.001*
60-64	0.90 [0.85-0.95]		0.96 [0.91-1.02]		0.91 [0.86-0.96]	
Statutory healthcare insurance scheme						
Salaried workers	Ref	<0.001	Ref	<0.001	Ref	<0.001
Civil servants	1.02 [0.96-1.09]		1.12 [1.04-1.20]		1.05 [0.98-1.12]	
Agricultural occupations	2.74 [1.78-4.21]		3.35 [2.17-5.18]		1.54 [0.98-2.44]	
Self-employed workers	3.76 [3.23-4.38]		2.77 [2.37-3.23]		1.55 [1.32-1.82]	
Large companies	1.38 [1.24-1.53]		1.50 [1.34-1.67]		1.24 [1.11-1.39]	
Previous mammography status^e						
At least 1 normal result in an OS programme	---		Ref	<0.001	Ref	<0.001
At least 1 abnormal in OS (false-positive findings)			1.50 [1.36-1.67]		1.18 [1.07-1.31]	
Previous mammography in OpS programmes only			2.06 [1.86-2.28]		1.81 [1.64-1.99]	
No previous mammography (OS or OpS)			5.82 [5.52-6.13]		1.86 [1.76-1.96]	
Level 2: Residence (area)						
European Deprivation Index						
Quintile 1 (least deprived)	Ref	<0.001	Ref	0.020	Ref	0.090
Quintile 2	1.25 [1.14-1.36]	<0.001*	1.12 [1.03-1.21]	0.030*	1.11 [1.03-1.19]	0.432*
Quintile 3	1.27 [1.17-1.39]		1.07 [0.99-1.16]		1.05 [0.98-1.14]	
Quintile 4	1.47 [1.35-1.61]		1.06 [0.98-1.15]		1.04 [0.96-1.12]	
Quintile 5 (most deprived)	1.74 [1.59-1.90]		1.14 [1.05-1.24]		1.07 [0.99-1.15]	
Local radiologist in area	0.94 [0.85-1.02]	0.144	---		---	
Random effects						
Level 2 variance (standard error)	0.04 [0.006]		0.02 [0.006]		0.01 [0.006]	
likelihood ratio test χ^2 (p)	<0.001		<0.001		0.008	
Intraclass correlation coefficient (%)	1.11% ^f		0.6% ^g		0.31% ^h	

OS, organized screening; OpS, opportunistic screening; aOR, adjusted odds ratio; CI, confidence interval; a. missing data in NP=1,948; b. missing data in PP1=7; c. missing data in PP2=4; d. *p* heterogeneity for non-ordinal variables with *, *p*-trend for ordinal variables ; e. Given the strong correlation between non-participation and previous mammography status, mammography was not introduced in the non-participation model [univariate OR_{absence of previous mammogram} = 8.9 [95%CI 8.5-9.4]]. OR_{Previous mammography in OpS programmes only} = NS (0.95 [0.8-1.1] ; OR_{At least 1 previous abnormal mammography (false-positive findings) in OS}= 1.4 [1.2-1.5]. f, g, h: ICC in empty models: 2.1%, 1%, and 0.4% ; Data extraction in January 2016. Invitation sent during November 2010 and October 2012.

Figure 1: Flow chart (2010-2015)