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Temporal trend in socio-economic inequalities in the uptake of cancer screening programs in France between 2005 and 2010: Results from the cancer barometer surveys

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ABSTRACT

Objectives: Cancer screening is a form of secondary prevention for a disease which is now the leading cause of death in France. Various socio-economic indicators have been identified as potential factors for disparities in cancer screening uptake. Our study aims to identify the socio-economic inequalities which persist for screening uptake, and to quantify these disparities over a 5-year period.

Setting: The Cancer barometer is a population-based survey carried out in 2005 and 2010 across France.

Participants: A total of 4000 randomly selected participants aged 15 to 85 years, are questioned on their participation in breast, cervical and colorectal cancer screening programs and their socio-economic profile.

Primary and secondary outcome measures: For each type of screening program, we calculated participation rates, odds ratios (OR) and relative inequality indices (RII) for participation, derived from logistic regression of socio-economic variables. Changes in participation between 2005 and 2010 were then analyzed.

Results: Participation rates for breast and colorectal screening increased significantly along the majority of socio-economic categories, whereas for cervical screening there were no significant changes between 2005 and 2010. The magnitude of RIIs for income decreased for all 3 screening programs in 2010. The relative inequalities for education in mammography (RII=0.40, 95% CI 0.18 to 0.90) and cervical smear (RII=0.35, 95% CI 0.20 to 0.60) were significant in 2005, and increased for cervical smear (RII=0.30, 95% CI 0.16 to 0.54) in 2010.

Conclusions: There is a persistence of socio-economic inequalities in uptake of non-organized cervical cancer screening. Conversely, organized screening programs for breast and colorectal

cancer saw a reduction in socio-economic inequalities. Deficiencies in knowledge of, access to and affordability of cancer screening programs are likely to be responsible for the socio-economic disparities in participation.

Key words: cancer screening, breast cancer, cervical cancer, social inequalities, cancer epidemiology

Strengths and limitations of this study

- First study to examine temporal changes in inequalities for cancer screening uptake in France using relative inequality index.
- Benefits from datasets of two identical questionnaires on cancer screening uptake, taken 5 years apart, using two comparable population samples, hence minimizing selection and information bias.
- Evolution in the format of colorectal screening program in terms of technique and age limits may have led to measured differences in uptake between 2005 and 2010.
- Residents of collective dwellings, hospitals and other institutions were excluded from the survey, limiting the generalisability of the findings.
- Rrelatively small number for certain socio-economic strata, reducing therefore the precision of some estimates.

INTRODUCTION

Screening for cancer is an important form of secondary prevention for a disease which is now a leading cause of death in France and worldwide [1]. The 2008 European report on cancer recommends that health systems focus their resources on cancer prevention and early detection rather than treatment alone, as the global disease burden of cancer threatens to become unsustainable in terms of financial costs, pressure on services, follow-up of patients and delivery of care [2].

To date, many European countries have rolled out screening programs for breast cancer, colorectal cancer, cervical cancer via mammography, faecal occult blood test (FOBT) and cervical smear, respectively [3, 4]. However, for these screening programs to have a significant effect on reducing cancer mortality, they require a minimum level of participation among the eligible population; for instance 70% for mammography, and 50% for FOBT [5]. Although the determinants of participation in screening programs are multiple, several studies have identified various indicators as potential explanatory factors for sub-optimal participation among populations.

We identified several publications from France, UK, USA, Italy, Denmark, Korea and Argentina, which identified variables shown to have a consistently significant effect on cancer screening uptake [6-19]. For breast cancer screening, various social and economic variables were found to be significant across the different studies. No recurring variable was observed, with the exception of participation in other screening programs [7, 17]. For cervical cancer screening, the variables identified as having a significant effect on uptake were more numerous, and notably consistent for income [7, 11, 19], education level [10-12, 17, 19], employment [6, 12, 17, 18] and private health insurance [6, 7, 17]. For colorectal screening, general practitioners' (GP) consultation [6, 7, 17, 18] was consistently shown to have a significant effect on uptake of screening across the

studies, as well as income [14, 16, 17]. However, it remains unclear whether the effect of these socio-economic variables on participation rates in screening programs persists over time.

We found only one study [6] that examined the temporal evolution in screening uptake rates along socio-economic strata in France. In this study, the authors found that inequalities for participation in breast and colorectal cancer screening persisted over the study period. Thus, we believe that there is a need to re-examine how these trends may have evolved with respect to expansion in the coverage and awareness of organized cancer screening programs. The third French National Cancer Action Plan for the 2014-2019 period has identified early detection of cancers as a primary priority [20]. Within this goal is the reduction of inequalities associated with cancer diagnosis, with the hope that it subsequently reduces incidence rates. Any widening or reduction in socio-economic inequalities in the uptake of screening programs that are identified may then be used to direct future policy of the French national cancer control plan, which specifically seeks to address this issue [20]. We aim therefore in the present study to identify the socio-economic inequalities which persist for screening uptake, and to quantify these disparities over a 5 year period in France.

MATERIALS AND METHODS

Study population

We used data from Cancer Barometer surveys, two telephone surveys on cancer-related knowledge, attitudes, beliefs and practices conducted by the French National Institute for Prevention and Health (INPES). Both two surveys were carried out on a representative random sample of the general population aged over 16 years old for the first survey and aged 15–85 years old for the second, living in France. We used a two-stage random sampling design. Residents of

collective dwellings, hospitals and other institutions were excluded from the surveys. Private households with telephones were included in the sample. The first sampling step was household selection (by phone number). Within each selected household, one French speaking person aged 15–85 was randomly selected using the "next birthday" method. The interviews were conducted using a computer-assisted telephone interview (CATI) system.

The 2005 Cancer Barometer sample [17], was comprised of 4046 participants aged over 16 years interviewed between April and June 2005. Female responded more often than men (2422 vs. 1624) and mean age of interviewees was 46.7 years. There were 226 individuals with missing observations in the 2005 Cancer Barometer sample, notably for all 3 of the dependent variables, and 7 out of 10 of the covariates and independent variables. These individuals terminated the survey prematurely, and were thus removed from the analysis as their data was non-contributive, leaving 3820 participants in the sample population. The 2010 Cancer Barometer sample was comprised of 3727 participants aged 15 to 85 interviewed during the first semester of 2010 [18]. The mean age was 44.6 years and the majority of participants were also female (2124 vs 1603).

Measures

Socio-economic indicators (independent variables) were as follows: education level (inferior, equal to, superior to baccalauréat), employment status (employed, unemployed, inactive), occupational class (farmer, trader, manager, professional, employee, manual worker, other), monthly income (below €1000, €1000-1500, above €1500) and health insurance (complementary vs. basic insurance coverage). The outcome variables were participation in breast, cervical and colorectal cancer screening programs (dependent variables). For breast cancer screening, participants aged over 40 years were asked if they had undergone mammography within the previous 2 years. For cervical cancer screening, participants aged over 20 years were asked if they had undertaken a cervical smear within the previous 3 years. For colorectal cancer screening,

participants aged 50-74 years were asked if they had undertaken a faecal occult blood test (FOBT) within their lifetime. Covariates included gender, smoking status, alcohol consumption, region, living in a couple and having a close relative with cancer. For the calculation of screening participation rates, we added filters to select the target population eligible for each of the 3 different screening programs. Breast screening by mammography: female gender and 49<age<75. Cervical screening by cervical smear: female gender and 24<age<66. Colorectal screening by FOBT: both genders where 49<age<75.

The weighting was based on the data of the 1999 and 2008 employment survey of the French population [21], taking into account age, gender, region, education level and number of persons per household [17]. This allowed us to effectively calculate age-adjusted standardized rates for screening participation, in addition to later adjusting the regression models on the covariates mentioned.

Statistical analysis

We calculated age-adjusted screening rates (AAR) for each stratum using the weighting provided by the INPES. The temporal evolution in the participation rate along each stratum between 2005 and 2010 was examined using a Chi squared test. The disparity within each socio-economic variable was calculated as the absolute difference between the AAR for the highest and lowest group within an ordinal or binary variable for the given year.

Odds ratios (OR) derived from univariate logistic regression of screening participation on each socio-economic variable separately were used as a measure of participation likelihood for each stratum of the 6 socio-economic variables. The model was adjusted on the covariates: gender (colorectal screening only), region, alcohol, smoking, living in couple and close relative with cancer. For categorical variables, the higher socio-economic position was used as the reference

group. The p-value for significance of the evolution of the odds ratios between 2005 and 2010 was calculated using an interaction term between the socio-economic variable and the time period, in order to be consistent with the methodology of previous studies on the topic [22, 23].

For ordinal variables of income and education level, we calculated the Relative Inequality Index (RII) as a measure of health inequality. Previous studies on health inequalities, including breast cancer screening uptake [4, 9], employed a similar methodology for examining temporal evolutions along ordered socio-economic strata [22, 24]. The RII takes into account the proportion of the population within each stratum of a categorical socio-economic variable, which is used to create a separate independent variable that ranges from 0 to 1. This variable is calculated as the mid-point of the proportion within each stratum, added to the proportion of the population in the preceding stratum, beginning with the most favorable stratum. The RII provides the magnitude of the inequality in screening rates by comparing the Odds ratio of the most favorable socio-economic strata with that of the least favorable. All statistical analysis was performed using SAS version 9.2.

RESULTS

Table 1 presents the demographic and socio-economic characteristics of the study populations. The screening participation rates included only the eligible populations for each program. Table 2 shows the Chi2 test for the change in participation rates along each socio-economic stratum between 2005 and 2010. For mammography, participation rates increased significantly ($p<0.05$) along all socio-economic strata, with the exception of farmers, managers, manual workers, unemployed, basic health insurance and education level superior to baccalauréat. For FOBT, participation rates increased significantly along all socio-economic strata between, with the exception of those unemployed or occupation classified as other. For cervical smear there were no significant changes in participation rates along any of the socio-economic strata, except for those

without complementary health insurance, which increased significantly from 52.51% to 71.0% (p=0.017).

Table 3 shows the results of the logistic regression models for mammography participation on each socio-economic variable separately, adjusted for covariates. In 2005, farmers, self-employed, employees and manual workers showed significantly reduced participation compared to managers/executives, whereas in 2010 only the association in manual workers remained significant. For income, those earning <€1000 (OR=0.49, 0.28-0.87) showed significantly reduced participation compared to those earning >€1500 in 2005, which became non-significant in 2010 (OR=0.75, 0.36-1.57). In 2005, those with an education inferior to baccalauréat (OR=0.55, 0.33-0.91) showed significantly reduced participation compared to those superior to baccalauréat, which became non-significant in 2010 (OR=0.98, 0.50-1.93).

Table 4 shows the results of the regression model for cervical smear participation for each socio-economic variable. In 2005, significantly reduced participation was observed for self-employed and manual workers, which became non-significant for both in 2010. In 2005, there was significantly reduced participation for those earning <€1000 and €1000-€1500, which remained significant in 2010 for those earning <€1000. An education level inferior to baccalauréat showed significantly lower participation in both 2005 and in 2010. In 2005, being unemployed or inactive significantly reduced participation, and remained significant for both in 2010. The odds ratio for cervical smear participation changed significantly (p=0.010) for those without complementary health insurance from 0.29 (0.17-0.49) in 2005 to 0.69 (0.41-1.17) in 2010. Having only basic health insurance was significantly associated with reduced participation in both periods.

Table 5 shows the logistic regression results for FOBT participation on each socio-economic variable. In 2005, those classified as inactive showed increased participation (OR=1.56, 1.19-2.03) compared with those employed, and remained significant in 2010 (OR=1.52, 1.18-1.96). For

occupation, manual workers (OR=0.63, 0.42-0.95) showed significantly reduced participation in 2010. Odds ratios for all other occupations showed reduced participation compared to managers, but at a non-significant level in 2005 and 2010. There were no significant temporal changes in any of the odds ratios for participation in breast or colorectal cancer screening between 2005 and 2010.

The regression of screening participation on income distribution produced RIIs which can be found in tables 3-5. The results showed significant inequalities for mammography (RII=0.36, 0.15-0.85) and cervical smear (RII=0.24, 0.13-0.46) in 2005, but not for FOBT (RII= 0.70, 0.38-1.28). The magnitude of the RIIs decreased for all 3 screening programs in 2010, meaning a reduction in income-based inequalities, and remained significant only for cervical smear (RII=0.28, 0.14-0.57). For education, mammography (RII=0.40, 0.18-0.90) and cervical smear (RII=0.35, 0.20-0.60) showed significant inequalities in 2005, whereas the RII for FOBT was non-significant (RII=0.69, 0.42-1.14). In 2010, the magnitude of the education RII decreased for mammography and became non-significant (RII=0.73, 0.23-2.24), whereas the RII for cervical smear increased and remained significant (RII=0.30, 0.16-0.54). The p-trend for the temporal change in the RIIs (adjusted model) measured by interaction term between 2005 and 2010, was found to be non-significant for all 3 screening programs for income and education level.

DISCUSSION

Our objectives were to determine along which socio-economic strata existed significant disparities in uptake for breast, cervical and colorectal screening and to examine if these disparities have changed between the 2005 and 2010 Cancer barometer surveys. In absolute terms, we found a significant increase in participation rates across all socio-economic strata for mammography and for FOBT between 2005 and 2010. Cervical cancer screening however saw no significant change in participation rates between 2005 and 2010 (except for those without complementary health

insurance). A similar trend was observed when relative inequalities were considered. It should be noted that some of these inequalities were persistent between 2005 and 2010, even though formal statistical tests for trend were generally not significant.

Findings in the context of the literature

It is encouraging to note the globally significant increase in participation rates across all socio-economic strata for mammography between 2005 and 2010. This effect was not demonstrated by a French study by Sicsic et al. on mammography participation rates in 2006, 2008 and 2010, which showed a decrease in participation rates over time [6]. This study did however show a large increase in colorectal cancer screening rates, in line with our findings. Cervical cancer screening however saw no significant change in participation rates between 2005 and 2010 (except for those without complementary health insurance), while Sicsic et al. showed an overall decrease in participation rates from 2006 to 2010. Our study confirmed significantly reduced participation for manual workers in breast and colorectal screening and for those with only basic health insurance in breast and cervical screening in 2010. This is consistent with Sicsic et al., which showed reduced participation in all 3 screening programs for manual workers and those with only basic health insurance.

Breast and colorectal cancer screening programs saw the absolute differences in participation rates reduced over time for all socio-economic variables in our study, with the exception of employment and basic health insurance. Sicsic et al. [6] found that disparities in participation did not decrease for mammography or FOBT screening from 2006 to 2010. An American study by Kim et al. showed the disparity in mammography participation based on income remained unchanged, while the disparity based on education decreased from 2000 to 2005 [9]. Cervical cancer screening

however saw a persisting disparity in participation rates for the majority of socio-economic variables in our study, consistent with the results of De Maio et al. [19] and Sicsic et al. [6].

The RII for income and education decreased for breast and colorectal cancer screening in our study, consistent with De Maio et al., which showed a decrease in the RII for breast cancer screening from 2005 to 2009 [19]. Whereas in the study by Kim et al. [9], the RII for income tended to decrease slightly and the RII for education remained constant over time. The cervical screening RII decreased for income and increased for education from 2005 to 2010 in our study, remaining statistically significant for both. This is consistent with the De Maio et al.[19], where the social gradient decreased for income and increased for education between 2005 and 2010.

Interpretation of results

The screening programs for breast and colorectal cancer are organized at a national level, and have seen their absolute differences in participation rates and relative inequalities reduced over time for all socio-economic variables. For both breast and colorectal screening, the odds ratios for manual workers showed reduced participation compared to managers/executives in 2010. Education and occupation are strongly correlated, with manual workers having a higher proportion of participants with an educational level inferior to baccalauréat (85%) than any other occupational category in 2010. Thus they may have been less aware of the health marketing campaigns for colorectal cancer screening and the recommendation of FOBT.

Cervical cancer screening remains without a nationally organized program in France, where it is the duty of their doctors to organize and for the individual two pay for the cervical smear. The lack of a nationally organised screening program may impose significant financial, educational and cultural barriers to screening uptake among certain sections of the French population. The financial costs for a consultation and laboratory processing of the screening test may deter those with only

basic health insurance, as public reimbursement covers only 70% of the cost [25]. This may account for the persistence of the observed differences in participation rates and large RIIs. Improving the awareness, affordability and access to cervical cancer screening should be prioritised in order to increase participation rates and reduce socio-economic disparities.

Limitations and strengths of the study

Our study availed of two almost identical datasets to construct a temporal analysis of participation in screening programs in France between 2005 and 2010. The use of relative inequality indices to measure the evolution of socio-economic inequalities in our study is the first to employ this methodology among a French population for cancer screening. The comparability of the study populations minimized selection bias and the conservation of the questionnaire format minimized information bias.

The study still has several limitations however. It shares the usual shortcomings of quantitative telephone surveys. There is a potential selection bias, as residents of collective dwellings, hospitals and other institutions were excluded from the survey. The study includes only those who are francophone, excluding individuals whose native language is not French. There was no available data on ethnicity or nationality of participants in the study, which may have been an important source of confounding or effect modification. Changes in screening policies concerning age limits, screening techniques and regional access left the 2005 and 2010 Cancer Barometers not directly comparable for certain programs. The question of screening participation for colorectal cancer was therefore limited to lifetime use of FOBT. Organized cervical screening was available in 13 regions in 2009, a source of regional variation not present in 2005. Some screening techniques are more memorable to patients, due to the invasiveness of the screening technique or the duration of the screening intervals, which may have led to recall bias.

The total sample population numbered approximately 4000 participants in each Barometer enquiry. However, disparities along socio-economic strata may not have been captured in the particular sample population, leading to false observations and conclusions. Missing observations for each variable accounted for less than 5% of the total population, except for the variable income (16.3% missing in 2005 and 9.3% in 2010). After filters had been applied to select the subpopulation eligible for screening, the remaining participants were of a relatively small number for certain socio-economic strata. This limited the precision of certain estimates, producing participation rates with large standard errors and odds ratios with large confidence intervals.

Conclusion

Despite these limitations, the present study represents a unique contribution to this topic. The findings suggest that organized screening programs have the potential to reduce socio-economic disparities in participation.

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Competing interest statement

All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf and declare: no support from any organisation for the submitted work; no financial relationships with any organisations that might have an interest in the submitted work in the previous three years; no other relationships or activities that could appear to have influenced the submitted work.

Contributors

DK reviewed the background literature, run statistical analyses and drafted the manuscript. CE, CL, PA provided advice on methodology and statistical analyses. CL & PA directed the data collection. HN conceived the study, advised on methodology, reviewed the results of statistical analyses and supervised the final edit of the manuscript. All authors contributed to the final draft of this manuscript.

Data sharing statement

All data presented in this manuscript came from 2 original datasets of the 2005 and 2010 Cancer Barometer surveys. The original files can be requested by contacting Santé Publique France (formerly INVS and INPES) via Pierre Arvidson (pierre.arwidson@santepubliquefrance.fr) or Christophe Léon (christophe.leon@santepubliquefrance.fr).

Table 1. Standardized† distribution of study populations for 2005 and 2010 Cancer Barometer surveys

Variables	Barometer 2005 (n=3820)		Barometer 2010 (n=3727)	
	n	%	n	%
Gender				
Male	1854	48,5	1790	48,0
Female	1966	51,5	1937	52,0
Region				
Ile-de-France	701	18,4	696	18,7
West Paris basin	380	10,0	348	9,3
East Paris basin	305	8,0	290	7,8
North	257	6,7	238	6,4
West	508	13,3	504	13,5
East	334	8,8	321	8,6
South West	414	10,9	412	11,1
South East	455	12,0	447	12,0
Mediterranée	457	12,0	471	12,6
Occupation				
Farmer	117	3,1	81	2,2
self-employed/craftsman	220	5,8	270	7,2
manager/executive	589	15,4	595	16,0
professional	773	20,3	914	24,5
employee/office worker	970	25,4	829	22,3
manual worker	642	16,8	839	22,5
other	506	13,3	199	5,3
Education level				
Inferior BAC	1946	52,0	2270	61,2
BAC	651	17,4	635	17,1
Superior BAC	1146	30,6	803	21,7
Monthly Income				
<€1000	414	13,2	399	12,1
€1000-1500	663	21,0	499	15,1
>€1500	2075	65,8	2401	72,8
Employment				
employed	2146	56,2	1851	49,7
unemployed	177	4,6	260	7,0
Inactive	1497	39,2	1615	43,3
Alcohol consumption				
Yes	3430	89,8	3195	85,7
No	389	10,2	532	14,3
Smoking status				
Yes	964	25,2	1195	32,1
No	2856	74,8	2532	67,9
Close Relative with cancer				
Yes	2366	62,1	2198	62,2
No	1446	37,9	1339	37,9
Living in couple				
Yes	2465	64,6	2333	62,6
No	1351	35,4	1394	37,4
Complementary Health Insurance				
Yes	3518	92,6	3210	89,6
No	282	7,4	375	10,5
Basic Health Insurance				
Yes	361	10,2	441	12,4
No	3182	89,8	3109	87,6
Mammography <2yrs				
Yes	499	43,6	325	28,0
No	645	56,4	836	72,0

Cervical smear <3yrs				
Yes	684	34,8	650	33,9
No	1282	65,2	1266	66,1
FOBT ever				
Yes	764	67,1	617	48,3
No	375	32,9	660	51,7

†Weighted by age, gender, region and educational level according to standard population of the 1999 and 2008 enquête emploi (INSEE)

Table 2. Standardised[†] participation rates for eligible participants in 3 screening programs, chi2 test for 2005-2010, p-trend

Socio-economic variable	Mammography			Cervical smear			FOBT		
	participation rate (%) ± SE			participation rate (%) ± SE			participation rate (%) ± SE		
	2005 (n=742)	2010 (n=804)	Chi2 p-value	2005 (n=1571)	2010 (n=1514)	Chi2 p-value	2005 (n=1222)	2010 (n=1425)	Chi2 p-value
Occupation									
farmer	62.49 ±8.24	87.64 ±8.81	0.148	75.61 ±7.28	80.39 ±11.63	0.739	26.97 ±6.69	56.50 ±10.82	0.006
self-employed	63.70 ±9.46	85.96 ±5.37	0.027	71.02 ±7.00	77.92 ±6.89	0.438	33.47 ±5.61	52.30 ±5.75	0.009
manager	85.50 ±4.04	91.45 ±2.50	0.262	85.15 ±2.51	83.88 ±3.05	0.740	39.33 ±3.89	57.33 ±3.31	0.0003
professional	74.87 ±3.74	87.82 ±2.95	0.004	84.31 ±1.95	88.17 ±1.68	0.153	35.04 ±3.21	53.32 ±2.79	<0,0001
employee	68.76 ±3.00	90.58 ±1.98	<0.0001	78.05 ±1.81	81.52 ±2.06	0.170	29.92 ±2.63	51.07 ±3.54	<0,0001
manual worker	64.52 ±6.01	76.02 ±5.29	0.161	74.70 ±3.96	75.00 ±4.22	0.956	30.29 ±3.74	46.95 ±4,23	0.001
other	69.37 ±6.19	83.70 ±5.28	0.097	81.14 ±4.21	62.94 ±6.53	0.010	32.87 ±6.20	43.84 ±6.92	0.204
Education level									
Inferior BAC	67.80 ±2.29	86.26 ±1.79	<0.0001	75.20 ±1.77	76.88 ±1.97	0.484	31.55 ±1.82	51.06 ±2.06	0
BAC	71.86 ±5.71	93.63 ±2.15	0.0003	83.59 ±2.47	86.42 ±2.03	0.385	32.07 ±4.46	56.06 ±3.58	<0,0001
Superior BAC	80.17 ±3.49	87.34 ±2.56	0.153	84.27 ±1.65	86.81 ±1.67	0.318	37.39 ±3.27	51.23 ±2.92	0.002
difference[*]	*12.37*	*1.08*		*9.07*	*9.93*		*5.84*	*0.17*	
Income									
<€1000	58.45 ±4.48	82.62 ±3.92	0.001	64.78 ±4.01	64.81 ±4.70	1	27.02 ±3.55	49.40 ±4.79	0.0001
€1000-1500	68.62 ±4.19	84.95 ±3.57	0.006	72.43 ±2.96	78.81 ±3.49	0.161	33.29 ±3.35	50.61 ±4.33	0.001
>€1500	76.21 ±2.65	89.57 ±1.59	<0.0001	85.21 ±1.25	84.96 ±1.36	0.885	37.07 ±2.23	52.29 ±1.96	<0,0001
difference	*17.76*	*6.95*		*20.43*	*20.15*		*10.05*	*2.89*	
Complementary health insurance									
yes	72.09 ±1.84	88.08 ±1.38	<0.0001	81.77 ±1.08	81.83 ±1.29	0.964	33.63 ±1.53	52.31 ± 1.64	<0,0001
No	48.35 ±9.53	78.06 ±7.49	0.013	52.51 ±6.04	71.00 ±5.67	0.017	20.10 ±5.58	41.51 ±7.71	0.011
difference	*23.76*	*10.02*		*29.26*	*10.83*		*13.53*	*10.80*	
Basic health insurance									
yes	66.12 ±7.38	69.98 ±8.60	0.694	67.20 ±4.70	67.22 ±5.47	1	26.23 ±4.56	52.75 ±6.93	0.0001
No	70.99 ±1.93	88.72 ±1.28	<0.0001	81.52 ±1.12	82.87 ±1.24	0.399	33.83 ±1.60	52.06 ±1.64	<0,0001
difference	*4.87*	*18.74*		*14.32*	*15.65*		*7.60*	*0.69*	
Employment									
employed	76.23 ±3.07	89.0 ±2.21	0.001	83.75 ±1.21	86.56 ±1.34	0.097	28.37 ±2.42	45.11 ±2.56	<0,0001
unemployed	66.26 ±9.44	84.1 ±8.73	0.176	66.00 ±5.25	72.88 ±5.23	0.304	25.48 ±6.60	35.91 ± 9.21	0.308
inactive	68.58 ±2.32	86.79 ±1.75	<0.0001	72.72 ±2.51	71.15 ±2.73	0.665	36.51 ±1.93	56.48 ±2.03	<0,0001

[†]Weighted by age, gender, region and educational level according to standard population of the 1999 and 2008 enquête emploi (INSEE)

Table 3. Association between socio-economic variables and the probability of participation in mammography in 2005 and 2010: Adjusted[†] and unadjusted OR

	Mammography 2005				Mammography 2010				
Socio-economic variable	**Unadjusted OR**	(95% CI)	**Adjusted OR**	(95% CI)	**Unadjusted OR**	(95% CI)	**Adjusted OR**	(95 % CI)	**p-trend[‡] 2005-2010**
Occupation									0,706
manager	**1,00**		**1.0**		**1,00**		**1.0**		
farmer	**0.28**	(0.10, 0,77)*	**0.31**	(0.11, 0,87)*	**0.66**	(0.08, 5,45)	**0.55**	(0.06, 4,82)	
self-employed	**0.30**	(0.11, 0,81)*	**0.31**	(0.11, 0,87)*	**0.57**	(0.18, 1,86)	**0.56**	(0.17, 1,88)	
professional	**0.51**	(0.23, 1,10)	**0.52**	(0.24, 1,16)	**0.67**	(0.26, 1,72)	**0.66**	(0.25, 1,72)	
employee	**0.37**	(0.18, 0,77)*	**0.39**	(0.19, 0,81)*	**0.90**	(0.36, 2,26)	**1.12**	(0.43, 2,94)	
Manual worker	**0.31**	(0.13, 0,74)*	**0.32**	(0.13, 0,79)*	**0.30**	(0.11, 0,78)*	**0.33**	(0.12, 0,92)*	
Other	**0.38**	(0.16, 0,95)*	**0.41**	(0.16, 1,04)	**0.48**	(0.16, 1,47)	**0.68**	(0.21, 2,25)	
Income									0,684
>€1500	**1,00**		**1,00**		**1,00**		**1,00**		
€1000-€1500	**0.68**	(0.42, 1,11)	**0.74**	(0.45, 1,21)	**0.66**	(0.34, 1,27)	**0.98**	(0.47, 2,06)	
<€1000	**0.44**	(0.26, 0,73)*	**0.49**	(0.28, 0,87)*	**0.55**	(0.29, 1,06)	**0.75**	(0.36, 1,57)	
RII	**0,29**	(0,14, 0,64)*	**0,36**	(0,15, 0,85)*	**0,37**	(0,13, 1,00)	**0,70**	(0,21, 2,31)	0.699
Education level									0,365
superior BAC	**1,00**		**1,00**		**1,00**		**1,00**		
BAC	**0.63**	(0.32, 1,26)	**0.61**	(0.30,1,23)	**2.13**	(0.73, 6,18)	**2.03**	(0.68, 6,02)	
inferior BAC	**0.52**	(0.32, 0,86)*	**0.55**	(0.33, 0,91)*	**0.91**	(0.48, 1,73)	**0.98**	(0.50, 1,93)	
RII	**0,36**	(0,16, 0,79)*	**0,40**	(0,18, 0,90)*	**0,62**	(0,21, 1,81)	**0,73**	(0,23, 2,24)	0.407
Employment									0,742
employed	**1,00**		**1,00**		**1,00**		**1,00**		
unemployed	**0.61**	(0.23, 1,62)	**0.60**	(0.23, 1,60)	**0.65**	(0.19, 2,20)	**0.70**	(0.19, 2,50)	
inactive	**0.68**	(0.46, 1,01)	**0.77**	(0.51, 1,15)	**0.81**	(0.49, 1,36)	**0.84**	(0.49, 1,45)	
Complementary health insurance									0,872
Yes	**1,00**		**1,00**		**1,00**		**1,00**		
No	**0.36**	(0.16, 0,81)*	**0.41**	(0.18, 0,95)	**0.48**	(0.22, 1,06)	**0.60**	(0.25, 1,43)	
Basic health insurance									0,111
Yes	**0.80**	(0.41, 1,54)*	**0.82**	(0.42, 1,59)	**0.30**	(0.15, 0,58)*	**0.39**	(0.19, 0,81)*	
No	**1,00**		**1,00**		**1,00**		**1,00**		

[†]Adjusted on the covariates: region, alcohol consumption, smoking status, close relative with cancer & living in couple

[‡]Calculated by the interaction term for the change in Adjusted OR and Adjusted RII between 2005 and 2010*p<0.05 **p<0.001

Table 4. Association between socio-economic variables and the probability of cervical smear participation in 2005 and 2010: Adjusted[†] and unadjusted OR

	Cervical smear 2005				Cervical smear 2010				
Socio-economic variable	**Unadjusted OR**	(95% CI)	**Adjusted OR**	(95 % CI)	**Unadjusted OR**	(95% CI)	**Adjusted OR**	(95% CI)	**p-trend[‡] 2005-2010**
Occupation									0,480
manager	**1,00**		**1.0**		**1,00**		**1.0**		
farmer	**0.54**	(0.20, 1,45)	**0.55**	(0.20, 1,52)	**0.79**	(0.19, 3,29)	**0.78**	(0.18, 3,35)	
self-employed	**0.43**	(0.20, 0,90)*	**0.41**	(0.19, 0,88)*	**0.68**	(0.31, 1,50)	**0.68**	(0.30, 1,52)	
professional	**0.94**	(0.57, 1,54)	**0.97**	(0.59, 1,61)	**1.43**	(0.89, 2,45)	**1.52**	(0.88, 2,62)	
employee	**0.62**	(0.40, 0,96)*	**0.65**	(0.41, 1,02)	**0.85**	(0.52, 1,37)	**0.89**	(0.54, 1,44)	
Manual worker	**0.52**	(0.29, 0,92)*	**0.50**	(0.28, 0,91)*	**0.58**	(0.33, 1,01)	**0.68**	(0.37, 1,22)	
Other	**0.75**	(0.38, 1,49)	**0.78**	(0.39, 1,58)	**0.33**	(0.18, 0,60)*	**0.49**	(0.25, 0,94)*	
Income									0,339
>€1500	**1,00**		**1,00**		**1,00**		**1,0**		
€1000-1500	**0.46**	(0.32, 0,65)**	**0.53**	(0.37, 0,77)**	**0.66**	(0.43, 1,01)	**0.76**	(0.48, 1,21)	
<€1000	**0.32**	(0.21, 0,49)**	**0.43**	(0.27, 0,68)**	**0.33**	(0.22, 0,49)**	**0.43**	(0.27, 0,69)**	
RII	**0,16**	(0,09, 0,28)**	**0,24**	(0,13, 0,46)**	**0,20**	(0,11, 0,37)**	**0,28**	(0,14, 0,57)**	0.268
Education level									0,822
superior BAC	**1,00**		**1,00**		**1,00**		**1,0**		
BAC	**0.95**	(0.63, 1,45)	**1.00**	(0.66, 1,54)	**0.97**	(0.59, 1,58)	**0.93**	(0.57, 1,53)	
inferior BAC	**0.57**	(0.41, 0,77)**	**0.56**	(0.41, 0,78)**	**0.51**	(0.35, 0,73)**	**0.53**	(0.36, 0,77)**	
RII	**0,36**	(0,21, 0,61)**	**0,35**	(0,2, 0,60)**	**0,28**	(0,16, 0,51)**	**0,3**	(0,16, 0,54)**	0.887
Employment									0,349
Employed	**1,00**		**1,00**		**1,00**		**1,0**		
Unemployed	**0.38**	(0.23, 0,61)**	**0.46**	(0.28, 0,75)*	**0.42**	(0.26, 0,67)**	**0.51**	(0.31, 0,83)*	
Inactive	**0.52**	(0.38, 0,71)**	**0.50**	(0.36, 0,69)**	**0.38**	(0.28, 0,52)**	**0.40**	(0.29, 0,55)**	
Complementary health insurance									0,010
Yes	**1,00**		**1,00**		**1,00**		**1,0**		
No	**0.25**	(0.15, 0,40)**	**0.29**	(0.17, 0,49)**	**0.54**	(0.34, 0,88)*	**0.69**	(0.41, 1,17)	
Basic health insurance									0,524
yes	**0.46**	(0.29, 0,74)*	**0.57**	(0.35, 0,92)*	**0.42**	(0.28, 0,65)**	**0.59**	(0.36, 0,95)*	
no	**1,00**		**1,00**		**1,00**		**1,00**		

[†]Adjusted on the covariates : region, alcohol consumption, smoking status, close relative with cancer & living in couple

[‡]Calculated by the interaction term for the change in Adjusted OR and Adjusted RII between 2005 and 2010*p<0.05 **p<0.001

Table 5. Association between socio-economic variables and the probability of FOBT participation in 2005 and 2010: Adjusted[†] and unadjusted OR

	FOBT 2005				FOBT 2010				
Socio-economic variable	**Unadjusted OR**	(95% CI)	**Adjusted OR**	(95% CI)	**Unadjusted OR**	(95% CI)	**Adjusted OR**	95% CI	**p-trend[‡] 2005-2010**
Occupation									0,301
Manager	**1,00**		**1.0**		**1,00**		**1.0**		
Farmer	**0.57**	(0.29, 1,10)	**0.66**	(0.34, 1,31)	**0.97**	(0.46, 2,05)	**0.78**	(0.35, 1,73)	
self-employed	**0.78**	(0.46, 1,31)	**0.74**	(0.43, 1,27)	**0.82**	(0.51, 1,31)	**0.82**	(0.50, 1,35)	
Professional	**0.83**	(0.57, 1,23)	**0.88**	(0.59, 1,30)	**0.85**	(0.60, 1,20)	**0.91**	(0.63, 1,31)	
Employee	**0.66**	(0.45, 0,96)*	**0.79**	(0.53, 1,17)	**0.78**	(0.54, 1,12)	**0.96**	(0.64, 1,44)	
Manual worker	**0.67**	(0.44, 1,03)	**0.68**	(0.44, 1,05)	**0.66**	(0.45, 0,96)*	**0.63**	(0.42, 0,95)*	
Other	**0.76**	(0.39, 1,46)	**0.94**	(0.47, 1,89)	**0.58**	(0.36, 0,95)*	**0.60**	(0.35, 1,02)	
Income									0,253
>€1500	**1,00**		**1,00**		**1,00**		**1,00**		
€1000-1500	**0.85**	(0.61, 1,18)	**0.93**	(0.66, 1,31)	**0.94**	(0.67, 1,31)	**1.11**	(0.77, 1,61)	
<€1000	**0.63**	(0.42, 0,94)*	**0.74**	(0.48, 1,15)	**0.89**	(0.62, 1,29)	**1.13**	(0.74, 1,72)	
RII	**0,54**	(0,31, 0,93)*	**0,70**	(0,38, 1,28)	**0,83**	(0,49, 1,41)	**0,80**	(0,43, 1,48)	0.275
Education level									0,485
superior BAC	**1,00**		**1,00**		**1,00**		**1,00**		
BAC	**0.79**	(0.50, 1,24)	**0.85**	(0.54, 1,33)	**1.21**	(0.81, 1,83)	**1.27**	(0.82, 1,97)	
inferior BAC	**0.77**	(0.58, 1,04)	**0.79**	(0.59, 1,07)	**0.99**	(0.74, 1,34)	**0.99**	(0.72, 1,36)	
RII	**0,67**	(0,41, 1,09)	**0,69**	(0,42, 1,14)	**0,90**	(0,56, 1,45)	**1,14**	(0,68, 1,36)	0.519
Employment									0,960
Employed	**1,00**		**1,00**		**1,00**		**1,00**		
Unemployed	**0.86**	(0.40, 1,88)	**1.08**	(0.49, 2,38	**0.68**	(0.37, 1,27)	**0.87**	(0.45, 1,68)	
Inactive	**1.45**	(1.12, 1,88)*	**1.56**	(1.19, 2,03)*	**1.58**	(1.25, 1,99)**	**1.52**	(1.18, 1,96)*	
Complementary health insurance									0,441
Yes	**1,00**		**1,00**		**1,00**		**1,00**		
No	**0.50**	(0.25, 0,97)*	**0.52**	(0.26, 1,04)	**0.65**	(0.40, 1,05)	**0.85**	(0.50, 1,45)	
Basic Health insurance									0,257
Yes	**0.70**	(0.43, 1,16)	**0.72**	(0.45, 1,16)	**1.03**	(0.69, 1,54)	**1.11**	(0.71, 1,72)	
No	**1,00**		**1,00**		**1,00**		**1,00**		

[†]Adjusted on the covariates : region, alcohol consumption, smoking status, close relative with cancer & living in couple

[‡]Calculated by the interaction term for the change in Adjusted OR and Adjusted RII between 2005 and 2010*p<0.05 **p<0.001

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found **YES**
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported **YES**
Objectives	3	State specific objectives, including any prespecified hypotheses **YES**
Methods		
Study design	4	Present key elements of study design early in the paper **YES**
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection **YES**
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants **YES**
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable **YES**
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group **YES**
Bias	9	Describe any efforts to address potential sources of bias
Study size	10	Explain how the study size was arrived at
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why **YES**
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding **YES**
		(*b*) Describe any methods used to examine subgroups and interactions **YES**
		(*c*) Explain how missing data were addressed **YES**
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy **YES**
		(*e*) Describe any sensitivity analyses

Continued on next page

Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed **YES**
		(b) Give reasons for non-participation at each stage **YES**
		(c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders **YES**
		(b) Indicate number of participants with missing data for each variable of interest **YES**
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures **YES**
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included **YES**
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period **YES**
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results	18	Summarise key results with reference to study objectives **YES**
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias **YES**
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence **YES**
Generalisability	21	Discuss the generalisability (external validity) of the study results **YES**
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based **YES**

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Temporal trend in socio-economic inequalities in the uptake of cancer screening programs in France between 2005 and 2010: Results from the Cancer Barometer Surveys

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Temporal trend in socio-economic inequalities in the uptake of cancer screening programs in France between 2005 and 2010: Results from the Cancer Barometer Surveys

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ABSTRACT

Objectives: Cancer screening is a form of secondary prevention for a disease which is now the leading cause of death in France. Various socio-economic indicators have been identified as potential factors for disparities in cancer screening uptake. Our study aimed to identify the socio-economic inequalities which persisted for screening uptake, and to quantify these disparities over a 5-year period.

Setting: The Cancer Barometer is a population-based survey carried out in 2005 and 2010 in Metropolitan France.

Participants: **A** randomly selected inhabitants aged 15 to 85 years, 3820 in 2005 and 3727 in 2010 were interviewed on their participation in breast, cervical and colorectal cancer screening programs and their socio-economic profile.

Primary and secondary outcome measures: For each type of screening program, we calculated participation rates, odds ratios (OR) and relative inequality indices (RII) for participation, derived from logistic regression of socio-economic variables. Changes in participation between 2005 and 2010 were then analyzed.

Results: Participation rates for breast and colorectal screening increased significantly along the majority of socio-economic categories, whereas for cervical screening there were no significant changes between 2005 and 2010. RIIs for income decreased for all 3 screening programs in 2010. RIIs for education in mammography (RII=0.40, 95% CI 0.18 to 0.90) and cervical smear (RII=0.35, 95% CI 0.20 to 0.60) were significant in 2005, and increased for cervical smear (RII=0.30, 95% CI 0.16 to 0.54) in 2010.

Conclusions: There was a persistence of socio-economic inequalities in uptake of opportunistic cervical cancer screening. Conversely, organized screening programs for breast and colorectal

cancer saw a reduction in socio-economic inequalities. Deficiencies in knowledge of, access to and affordability of cancer screening are likely to be responsible for the socio-economic disparities in participation.

Key words: cancer screening, breast cancer, cervical cancer, social inequalities, cancer epidemiology

Strengths and limitations of this study

- First study to examine temporal changes in inequalities for cancer screening uptake in France using relative inequality index.
- Benefits from datasets of two identical questionnaires on cancer screening uptake, taken 5 years apart, using two comparable population samples, hence minimizing information bias.
- Evolution in the format of colorectal screening program in terms of technique and age limits may have led to measured differences in uptake between 2005 and 2010.
- Residents of nursing homes and other medical institutions without a personal telephone line were excluded from the survey, limiting the generalisability of the findings.
- Relatively small number for certain socio-economic strata, reducing therefore the precision of some estimates.

INTRODUCTION

Screening for cancer is an important form of secondary prevention for a disease which is now leading cause of death in France and worldwide [1].The 2008 European report on cancer recommends that health systems focus their resources on cancer prevention and early detection rather than treatment alone, as the global disease burden of cancer threatens to become unsustainable in terms of financial costs, pressure on services, follow-up of patients and delivery of care [2].

To date, many European countries have rolled out screening programs for breast cancer, colorectal cancer, cervical cancer via mammography, faecal occult blood test (FOBT) and cervical smear, respectively [3,4]. However, for these screening programs to have a significant effect on reducing cancer mortality, they require a minimum level of participation among the eligible population; for instance 70% for mammography, and 50% for FOBT [5].

We reviewed several publications from France, UK, USA, Italy, Denmark, Korea and Argentina, which identified variables shown to have a significant effect on cancer screening uptake [6-19]. For breast cancer screening, various different social and economic variables were found to have an effect, including employment, living in a couple, occupation, education level, income, private health insurance, car/home ownership and rural residency. However, no single variable was consistently observed across studies except for participation in other screening programs [7,17]. For cervical cancer screening, the variables identified as having a significant effect on uptake were more numerous, and notably consistent for income [7,11,19], education level [10-12,17,19], employment [6,12,17,18] and private health insurance [6,7,17]. For colorectal screening, general practitioners' (GP) consultation [6,7,17,18] was consistently shown to have a significant effect on uptake of screening across the studies, as well as income [14,16,17]. However, it remains unclear

whether the effect of these socio-economic variables on participation rates in screening programs persists over time.

Only one study drawn from the 2006, 2008 and 2010 French Healthcare and Health Insurance surveys [1] has examined the temporal evolution in breast, cervical and colorectal cancer screening uptake along socio-economic strata in France to date. This study conducted among 10 000 participants found that those classified as unskilled workers were less likely to have undergone cervical cancer screening (OR = 1.64 [1.38-1.95]). The results also showed that women without (OR = 2.05 [1.68-2.51]) or receiving free complementary health insurance (OR = 1.79 [1.36-2.37]) were less likely to have undergone breast cancer screening. In this study, the authors found that inequalities for participation in breast and colorectal cancer screening persisted over the study period from 2006 to 2010.Thus, we believe that there is a need to re-examine how these trends may have evolved with respect to expansion in the coverage and awareness of organized cancer screening programs. The third French National Cancer Action Plan for the 2014-2019 period has identified early detection of cancers as a primary priority [20]. Within this goal is the reduction of inequalities associated with cancer diagnosis, with the hope that it subsequently reduces mortality rates. Any widening or reduction in socio-economic inequalities in the uptake of screening programs that are identified may then be used to direct future policy of the French national cancer control plan, which specifically seeks to address this issue [20]. We aim therefore in the present study to identify the socio-economic inequalities which persist for uptake of breast, cervical and colorectal cancer screening, and to quantify these disparities over a 5 year period in France.

MATERIALS ANDMETHODS

Study population

We used data, obtained by formal permission, from the Cancer Barometer surveys, two telephone surveys on cancer-related knowledge, attitudes and practices conducted by the French National Institute for Prevention and Health (now part of Santé Publique France). Both surveys were carried out on a representative random sample of the general French population aged over 16 years old for the 2005 survey and aged 15–85 years old for the 2010 survey. A two-stage random sampling design was used. Residents of nursing homes or other medical institutions who did not possess a personal telephone line were not included in the samples. Private households with telephones were included in the sample. The first sampling step was household selection (by phone number). Within each selected household, one French speaking person aged 15–85 was randomly selected using the "next birthday" method. The interviews were conducted using a computer-assisted telephone interview (CATI) system.

In order to obtain adequate statistical power for measuring associations between variables and changes in participation rates along smaller levels, a sample size of between 3500 and 4000 was deemed appropriate. The 2005 Cancer Barometer sample [17],was comprised of 4046 participants aged over 16 years interviewed between April and June 2005.There were 226 individuals with missing observations in the 2005 Cancer Barometer sample, notably for all 3 of the dependent variables, and 7 out of 10 of the covariates and independent variables. These individuals terminated the survey prematurely, and were thus removed from the analysis as their data was non-contributive, leaving 3820 participants in the sample population. Females (51.5%) responded more often than males (48.5%) and mean age of interviewees was 46.7 years. The 2010 Cancer Barometer sample was comprised of 3727 participants aged 15 to 85 interviewed during the first semester of 2010 [18]. The mean age was 44.6 years and the majority of participants were also

female (52.0% vs. 48.0%). The response rates for the 2005 and 2010 Cancer Barometers were 51.2% and 47.0%, respectively.

Measures

Socio-economic indicators (independent variables) were as follows: education level (inferior, equal to or superior to Baccalauréat (High-School Degree), employment status (employed, unemployed, and inactive), occupational class (farmer, trader, manager, professional, employee, manual worker, other), monthly income (below €1000, €1000-1500, above €1500) and health insurance (complementary vs. basic insurance coverage). The outcome variables were participation in breast, cervical and colorectal cancer screening programs (dependent variables). For breast cancer screening, participants aged over 40 years were asked if they had undergone mammography within the previous 2 years. For cervical cancer screening, participants aged over 20 years were asked if they had undergone a cervical smear within the previous 3 years. For colorectal cancer screening, participants aged 50-74 years were asked if they had undergone a faecal occult blood test (FOBT) within their lifetime. Covariates included gender, smoking status, alcohol consumption, region, living in a couple and having a close relative with cancer. For the calculation of screening participation rates, we added filters to select the target population eligible for each of the 3 different screening programs. Breast screening by mammography (n=1546): female gender and 49<age<75. Cervical screening by cervical smear (n=3085): female gender and 24<age<66. Colorectal screening by FOBT (n=2647): both genders where 49<age<75.

The weighting was based on the data of the 1999 and 2008 Employment Survey of the French population [21], taking into account age, gender, region, education level and number of persons per household [17].This allowed us to effectively calculate age-adjusted standardized rates for

screening participation, in addition to later adjusting the regression models on the covariates mentioned.

Statistical analysis

We calculated age-adjusted screening rates (AAR) for each stratum using the weighting provided by the INPES. The temporal evolution in the participation rate along each stratum between 2005 and 2010 was examined by adding an interaction term with the year of the survey. The disparity within each socio-economic variable was calculated as the absolute difference between the AAR for the highest and lowest group within an ordinal or binary variable for the given year.

Odds ratios (OR) derived from multiple logistic regression of screening participation on each socio-economic variable separately were used as a measure of participation likelihood for each stratum of the 6 socio-economic variables. The model was adjusted on the covariates: gender (colorectal screening only), region, alcohol, smoking, living in couple and close relative with cancer. For categorical variables, the higher socio-economic position was used as the reference group. The p-value for significance of the evolution of the odds ratios between 2005 and 2010 was calculated using an interaction term between the socio-economic variable and the time period, in order to be consistent with the methodology of previous studies on the topic [22,23].

For ordinal variables of income and education level, we calculated the Relative Inequality Index (RII) as a measure of health inequality as described by Mackenbach and Kunst [24]. Previous studies on health inequalities, including breast cancer screening uptake [4,9], employed a similar methodology for examining temporal evolutions along ordered socio-economic strata [22,25]. The RII is a regression-based measure that summarizes the association between two variables. It is computed by ranking income and education values on a scale from the lowest, which is 0, to the highest, which is 1. Each income or education level value covers a range on this scale that is

proportional to the number of participants who held that value and is given a new value on the scale corresponding to the cumulative midpoint of its range. The RII resembles relative risk in that it compares the probability of cancer screening uptake at the extremes of income and educational levels, but is estimated using the data on all income and education values and is weighted to account for the distribution of these values. Here the RII was fitted using logistic regression models. An RII of 0.5 for example indicates a lower probability of cancer screening uptake at the lower extreme of income and education levels compared to the higher extremes or vice versa. All statistical analysis was performed using SAS version 9.2.

RESULTS

Table 1 presents the demographic and socio-economic characteristics of the study populations. The overall participation rates among the eligible populations for breast, cervical and colorectal cancer screenings are shown in Table 2. Chi-squared tests for the change in participation rates along each socio-economic stratum between 2005 and 2010 are also included. For mammography, participation rates increased significantly ($p<0.05$) along all socio-economic strata, with the exception of farmers, managers, manual workers, unemployed, basic health insurance and education level superior to Baccalauréat. For FOBT, participation rates increased significantly along all socio-economic strata between, with the exception of those unemployed or occupation classified as other. For cervical smear there were no significant changes in participation rates along any of the socio-economic strata, except for those without complementary health insurance, which increased significantly from 52.51% to 71.0% ($p=0.017$).

Table 3 shows the results of the logistic regression models for mammography participation on each socio-economic variable separately, adjusted for covariates. In 2005, farmers, self-employed, employees and manual workers showed significantly reduced participation compared to

managers/executives, whereas in 2010 only the association in manual workers remained significant. For income, those earning <€1000 (OR=0.49, 0.28-0.87) showed significantly reduced participation compared to those earning >€1500 in 2005, which became non-significant in 2010 (OR=0.75, 0.36-1.57). In 2005, those with an education inferior to Baccalauréat (OR=0.55, 0.33-0.91) showed significantly reduced participation compared to those superior to Baccalauréat, which became non-significant in 2010 (OR=0.98, 0.50-1.93).

Table 4 shows the results of the regression model for cervical smear participation for each socio-economic variable. In 2005, significantly reduced participation was observed for self-employed and manual workers, which became non-significant for both in 2010. In 2005, there was significantly reduced participation for those earning <€1000 and €1000-€1500, which remained significant in 2010 for those earning <€1000. An education level inferior to Baccalauréat showed significantly lower participation in both 2005 and in 2010. In 2005, being unemployed or inactive significantly reduced participation, and remained significant for both in 2010. The odds ratio for cervical smear participation changed significantly (p=0.010) for those without complementary health insurance from 0.29 (0.17-0.49) in 2005 to 0.69 (0.41-1.17) in 2010. Having only basic health insurance was significantly associated with reduced participation in both periods.

Table 5 shows the logistic regression results for FOBT participation on each socio-economic variable. In 2005, those classified as inactive showed increased participation (OR=1.56, 1.19-2.03) compared with those employed, and remained significant in 2010 (OR=1.52, 1.18-1.96). For occupation, manual workers (OR=0.63, 0.42-0.95) showed significantly reduced participation in 2010. Odds ratios for all other occupations showed reduced participation compared to managers, but at a non-significant level in 2005 and 2010. There were no significant temporal changes in any of the odds ratios for participation in breast or colorectal cancer screening between 2005 and 2010.

The regression of screening participation on income distribution produced RIIs which can be found in Tables 3-5. The results showed significant inequalities for mammography (RII=0.36, 0.15-0.85) and cervical smear (RII=0.24, 0.13-0.46) in 2005, but not for FOBT (RII= 0.70, 0.38-1.28). The income-based RIIs decreased for all 3 screening programs in 2010, meaning reduction in income-based inequalities, and remained significant only for cervical smear (RII=0.28, 0.14-0.57). For education, mammography (RII=0.40, 0.18-0.90) and cervical smear (RII=0.35, 0.20-0.60) showed significant inequalities in 2005, whereas the RII for FOBT was non-significant (RII=0.69, 0.42-1.14). In 2010, the education-based RII decreased for mammography and became non-significant (RII=0.73, 0.23-2.24), whereas the RII for cervical smear increased and remained significant (RII=0.30, 0.16-0.54). The p-trend for the temporal change in the RIIs (adjusted model) measured by interaction term between 2005 and 2010, was found to be non-significant for all 3 screening programs for income and education level.

DISCUSSION

Our objective was to identify the socio-economic inequalities which persisted for uptake of breast, cervical and colorectal cancer screening, and to quantify these disparities between the 2005 and 2010. In absolute terms, we found a significant increase in participation rates across all socio-economic strata for mammography and for FOBT between 2005 and 2010. Cervical cancer screening however saw no significant change in participation rates between 2005 and 2010 (except for those without complementary health insurance). A similar trend was observed when relative inequalities were considered. It should be noted that some of these inequalities were persistent between 2005 and 2010, even though formal statistical tests for trend were generally not significant.

Findings in the context of the literature

It is encouraging to note the significant increase in participation rates across all socio-economic strata for mammography between 2005 and 2010. This effect was not demonstrated in a French study by Sicsic et al. in 2006, 2008 and 2010, which showed a decrease in mammography participation rates over time [6]. This study did however show a large increase in colorectal cancer screening rates, in line with our findings. Cervical cancer screening however saw no significant change in participation rates between 2005 and 2010 (except for those without complementary health insurance), while Sicsic et al. showed an overall decrease in participation rates from 2006 to 2010.Our study confirmed significantly reduced participation for manual workers in breast and colorectal screening and for those with only basic health insurance in breast and cervical screening in 2010. This is consistent with Sicsic et al., which showed reduced participation in all 3 screening programs for manual workers and those with only basic health insurance.

Several factors may explain why some of our findings differ from those by Sicsic et al [6]. Their study was based on data collected using three modalities: telephone, face-to-face and self-administered questionnaires. The Cancer Barometer data used in our study was collected exclusively via telephone interview. In addition, the study by Sicsic et al. was based on three surveys carried out in 2006, 2008 and 2010, with therefore a two-year interval, whereas the Cancer Barometer survey was conducted at two points in time in 2005 and 2010. Another important difference between the two studies relies on their objectives and consequently on the methods used to reach them. The study by Sicsic et al. aimed to analyze the obstacles to and levers for breast, cervical, and colorectal cancer screening uptake and their trends over time, whereas the aim of our study was to identify the socio-economic inequalities which persist for uptake of breast, cervical and colorectal cancer screening, and to quantify these disparities over a 5 year period. Thus, Sicsic

et al. pooled their three samples and did not conduct direct comparisons of associations between indicators of socioeconomic position and uptake of cancer screenings between periods.

Breast and colorectal cancer screening programs saw the absolute differences in participation rates reduced over time for all socio-economic variables in our study, with the exception of employment and basic health insurance. Sicsic et al.[6]found that disparities in participation did not decrease for mammography or FOBT screening from 2006 to 2010. An American study by Kim et al. showed the disparity in mammography participation based on income remained unchanged, while the disparity based on education decreased from 2000 to 2005 [9]. Cervical cancer screening however saw a persisting disparity in participation rates for the majority of socio-economic variables in our study, consistent with the results of De Maio et al. [19] and Sicsic et al.[6].

The relative inequalities for income and education decreased for breast and colorectal cancer screening in our study, consistent with De Maio et al., which showed a reduction in the RII for breast cancer screening from 2005 to 2009 [19]. In the study by Kim et al.[9], the income-based relative inequalities tended to decrease slightly, while those for education remained constant over time. The relative inequalities for cervical cancer screening decreased for income and increased for education from 2005 to 2010 in our study, both remaining statistically significant. This is consistent with the De Maio et al.[19], where the social gradient decreased for income and increased for education between 2005 and 2010.

Interpretation of results

Breast and colorectal screening programs are organized at a national level and differences in absolute participation rates and relative inequalities decreased over time for all socio-economic variables. For both breast and colorectal screening, the odds ratios for manual workers showed reduced participation compared to managers/executives in 2010. Education and occupation are

strongly correlated, with manual workers having a higher proportion of participants with an educational level inferior to Baccalauréat (85%) than any other occupational category in 2010. Thus they may have been less aware of the health marketing campaigns for colorectal cancer screening and the recommendation of FOBT.

Cervical cancer remains without a nationally organized screening program in France. It is the duty of doctors to organize and falls to the individual to pay for opportunistic screening via cervical smear test. The lack of a nationally organised screening program may impose significant financial, educational and cultural barriers to screening uptake among certain sections of the French population. The financial costs for a consultation and laboratory processing of the screening test may deter those with only basic health insurance, as public reimbursement covers only 70% of the cost [26]. This may account for the persistence of the observed differences in participation rates and large RIIs. Improving the awareness, affordability and access to cervical cancer screening should be prioritised in order to increase participation rates and reduce socio-economic disparities.

Those classified as inactive (retired, homemakers) may have more free time to attend for colorectal cancer screening, explaining therefore the increased FOBT participation. It is possible that a greater proportion of inactive people is retired and hence falls within the eligible population for FOBT screening (50 to 74 years), compared with younger employed group.

Limitations and strengths of the study

Our study used two almost identical datasets to construct a temporal analysis of participation in screening programs in France between 2005 and 2010. The use of relative inequality indices to measure the evolution of socio-economic inequalities in our study is the first to employ this methodology among a French population for cancer screening. The comparability of the study populations minimized selection bias and the conservation of the questionnaire format minimized information bias.

The study still has several limitations however. It shares the usual shortcomings of phone surveys. There is a potential selection bias, as residents of nursing homes or other medical institutions who did not possess a personal telephone line were not included in the samples. The study includes only those who are French speakers, excluding individuals unable to answer fluently in French. There was no available data on ethnicity or nationality of participants in the study, which may have been an important source of confounding or effect modification. The exclusion of the above subpopulations, which are likely to be more socio-economically disadvantaged, may have overestimated the screening participation rates in our study.

Changes in screening policies concerning age limits, screening techniques and regional access left the 2005 and 2010 Cancer Barometers not directly comparable for certain programs. The question of screening participation for colorectal cancer was therefore limited to lifetime use of FOBT. Organized cervical screening was available in 13 regions in 2009, a source of regional variation not present in 2005. Some screening techniques are more memorable to patients, due to the invasiveness of the screening technique or the duration of the screening intervals, which may have led to recall bias.

The respective analytical sample sizes in 2005 and 2010 for breast (n=742, n=804), cervical (n=1571, n=1514) and colorectal (n=1222, n=1425) cancer screening may have been too small to capture disparities along socio-economic strata, leading to false observations and conclusions. Missing observations for each variable accounted for less than 5% of the total population, except for the variable income (16.3% missing in 2005 and 9.3% in 2010). This limited the precision of certain estimates, producing participation rates with large standard errors and odds ratios with large confidence intervals. We undertook multiple comparisons in our study. Thus, we cannot exclude that some of the results we have observed are due to chance.

Conclusion

The findings suggest that organized cancer screening programs have the potential to reduce socio-economic disparities in participation.

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Competing interest statement

All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf and declare: no support from any organisation for the submitted work; no financial relationships with any organisations that might have an interest in the submitted work in the previous three years; no other relationships or activities that could appear to have influenced the submitted work.

Contributors

HN conceived the study, advised on methodology, reviewed the results of statistical analyses and supervised the final edit of the manuscript. DK reviewed the background literature, run statistical analyses and drafted the manuscript. CE, CL, PA provided advice on methodology and statistical analyses. CL & PA directed the data collection. All authors contributed to the final draft of this manuscript.

Data sharing statement

All data presented in this manuscript came from 2 original datasets of the 2005 and 2010 Cancer Barometer surveys. The original files can be requested by contacting Santé Publique France (formerly INVS and INPES) via Pierre Arvidson (pierre.arwidson@santepubliquefrance.fr) or Christophe Léon (christophe.leon@santepubliquefrance.fr).

Table 1. Standardized distribution of study populations for 2005 and 2010 Cancer Barometer surveys, p-value for Chi-squared test

Variables	Barometer 2005 (n=3820)		Barometer 2010 (n=3727)		p-value
	n	%	n	%	
Gender					0.660
Male	1854	48,5	1790	48,0	
Female	1966	51,5	1937	52,0	
Region					0.976
Ile-de-France	701	18,4	696	18,7	
West Paris basin	380	10,0	348	9,3	
East Paris basin	305	8,0	290	7,8	
North	257	6,7	238	6,4	
West	508	13,3	504	13,5	
East	334	8,8	321	8,6	
South West	414	10,9	412	11,1	
South East	455	12,0	447	12,0	
Mediterranée	457	12,0	471	12,6	
Occupation					<0.001
Farmer	117	3,1	81	2,2	
Self-employed/craftsman	220	5,8	270	7,2	
Manager/executive	589	15,4	595	16,0	
Professional	773	20,3	914	24,5	
Employee/office worker	970	25,4	829	22,3	
Manuel worker	642	16,8	839	22,5	
Oher	506	13,3	199	5,3	
Education level					<0.001
Inferior BAC*	1946	52,0	2270	61,2	
BAC	651	17,4	635	17,1	
Superior BAC	1146	30,6	803	21,7	
Monthly Income					<0.001
<€1000	414	13,2	399	12,1	
€1000-1500	663	21,0	499	15,1	
>€1500	2075	65,8	2401	72,8	
Employment					<0.001
Employed	2146	56,2	1851	49,7	
Unemployed	177	4,6	260	7,0	
Inactive	1497	39,2	1615	43,3	
Alcohol consumption					<0.001
Yes	3430	89,8	3195	85,7	
No	389	10,2	532	14,3	
Smoking status					<0.001
Yes	964	25,2	1195	32,1	
No	2856	74,8	2532	67,9	
Close Relative with cancer					0.950
Yes	2366	62,1	2198	62,1	
No	1446	37,9	1339	37,9	
Living in couple					0.071
Yes	2465	64,6	2333	62,6	
No	1351	35,4	1394	37,4	
Complementary Health Insurance					<0.001
Yes	3518	92,6	3210	89,6	
No	282	7,4	375	10,5	
Basic Health Insurance					0.003
Yes	361	10,2	441	12,4	
No	3182	89,8	3109	87,6	

* BAC = Baccalauréat (High-School degree)

Table 2. Standardised† participation rates for eligible participants in 3 screening programs, Chi-squared test for 2005-2010, *p*-trend

Socio-economic variable	Mammography			Cervical smear			FOBT		
	participation rate (%) ± SE			participation rate (%) ± SE			participation rate (%) ± SE		
	2005 (n=742)	2010 (n=804)	Chi2 *p*-value	2005 (n=1571)	2010 (n=1514)	Chi2 *p*-value	2005 (n=1222)	2010 (n=1425)	Chi2 *p*-value
Overall	88.0	88.3		79.7	81.4		34.0	51.6	
Occupation									
Farmer	62.49 ±8.24	87.64 ±8.81	0.148	75.61 ±7.28	80.39 ±11.63	0.739	26.97 ±6.69	56.50 ±10.82	0.006
Self-employed	63.70 ±9.46	85.96 ±5.37	0.027	71.02 ±7.00	77.92 ±6.89	0.438	33.47 ±5.61	52.30 ±5.75	0.009
Manager	85.50 ±4.04	91.45 ±2.50	0.262	85.15 ±2.51	83.88 ±3.05	0.740	39.33 ±3.89	57.33 ±3.31	0.0003
Pprofessional	74.87 ±3.74	87.82 ±2.95	0.004	84.31 ±1.95	88.17 ±1.68	0.153	35.04 ±3.21	53.32 ±2.79	<0,0001
Employee	68.76 ±3.00	90.58 ±1.98	<0.0001	78.05 ±1.81	81.52 ±2.06	0.170	29.92 ±2.63	51.07 ±3.54	<0,0001
Manual worker	64.52 ±6.01	76.02 ±5.29	0.161	74.70 ±3.96	75.00 ±4.22	0.956	30.29 ±3.74	46.95 ±4,23	0.001
Other	69.37 ±6.19	83.70 ±5.28	0.097	81.14 ±4.21	62.94 ±6.53	0.010	32.87 ±6.20	43.84 ±6.92	0.204
Education level									
Inferior BAC	67.80 ±2.29	86.26 ±1.79	<0.0001	75.20 ±1.77	76.88 ±1.97	0.484	31.55 ±1.82	51.06 ±2.06	0
BAC	71.86 ±5.71	93.63 ±2.15	0.0003	83.59 ±2.47	86.42 ±2.03	0.385	32.07 ±4.46	56.06 ±3.58	<0,0001
Superior BAC	80.17 ±3.49	87.34 ±2.56	0.153	84.27 ±1.65	86.81 ±1.67	0.318	37.39 ±3.27	51.23 ±2.92	0.002
Difference	*12.37*	*1.08*		*9.07*	*9.93*		*5.84*	*0.17*	
Income									
<€1000	58.45 ±4.48	82.62 ±3.92	0.001	64.78 ±4.01	64.81 ±4.70	1	27.02 ±3.55	49.40 ±4.79	0.0001
€1000-1500	68.62 ±4.19	84.95 ±3.57	0.006	72.43 ±2.96	78.81 ±3.49	0.161	33.29 ±3.35	50.61 ±4.33	0.001
>€1500	76.21 ±2.65	89.57 ±1.59	<0.0001	85.21 ±1.25	84.96 ±1.36	0.885	37.07 ±2.23	52.29 ±1.96	<0,0001
difference	*17.76*	*6.95*		*20.43*	*20.15*		*10.05*	*2.89*	
Complementary health insurance									
Yes	72.09 ±1.84	88.08 ±1.38	<0.0001	81.77 ±1.08	81.83 ±1.29	0.964	33.63 ±1.53	52.31 ± 1.64	<0,0001
No	48.35 ±9.53	78.06 ±7.49	0.013	52.51 ±6.04	71.00 ±5.67	0.017	20.10 ±5.58	41.51 ±7.71	0.011
difference	*23.76*	*10.02*		*29.26*	*10.83*		*13.53*	*10.80*	
Basic health insurance									
Yes	66.12 ±7.38	69.98 ±8.60	0.694	67.20 ±4.70	67.22 ±5.47	1	26.23 ±4.56	52.75 ±6.93	0.0001
No	70.99 ±1.93	88.72 ±1.28	<0.0001	81.52 ±1.12	82.87 ±1.24	0.399	33.83 ±1.60	52.06 ±1.64	<0,0001
difference	*4.87*	*18.74*		*14.32*	*15.65*		*7.60*	*0.69*	
Employment									
Employed	76.23 ±3.07	89.0 ±2.21	0.001	83.75 ±1.21	86.56 ±1.34	0.097	28.37 ±2.42	45.11 ±2.56	<0,0001
Unemployed	66.26 ±9.44	84.1 ±8.73	0.176	66.00 ±5.25	72.88 ±5.23	0.304	25.48 ±6.60	35.91 ± 9.21	0.308
nactive	68.58 ±2.32	86.79 ±1.75	<0.0001	72.72 ±2.51	71.15 ±2.73	0.665	36.51 ±1.93	56.48 ±2.03	<0,0001

†Weighted by age, gender, region and educational level according to standard population of the 1999 and 2008 Employment Surveys (INSEE)

Table 3. Association between socio-economic variables and the probability of participation in mammography in 2005 and 2010: unadjusted[†] and adjusted Odds Ratios

	Mammography 2005 (n=742)				Mammography 2010 (n=804)				
Socio-economic variable	**Unadjusted OR**	(95% CI)	**Adjusted OR**	(95% CI)	**Unadjusted OR**	(95% CI)	**Adjusted OR**	(95 % CI)	***p*-trend[‡] 2005-2010**
Occupation									0,706
Manager	**1,00**		**1.0**		**1,00**		**1.0**		
Farmer	**0.28**	(0.10, 0,77)*	**0.31**	(0.11, 0,87)*	**0.66**	(0.08, 5,45)	**0.55**	(0.06, 4,82)	
Self-employed	**0.30**	(0.11, 0,81)*	**0.31**	(0.11, 0,87)*	**0.57**	(0.18, 1,86)	**0.56**	(0.17, 1,88)	
Professional	**0.51**	(0.23, 1,10)	**0.52**	(0.24, 1,16)	**0.67**	(0.26, 1,72)	**0.66**	(0.25, 1,72)	
Employee	**0.37**	(0.18, 0,77)*	**0.39**	(0.19, 0,81)*	**0.90**	(0.36, 2,26)	**1.12**	(0.43, 2,94)	
Manual worker	**0.31**	(0.13, 0,74)*	**0.32**	(0.13, 0,79)*	**0.30**	(0.11, 0,78)*	**0.33**	(0.12, 0,92)*	
Other	**0.38**	(0.16, 0,95)*	**0.41**	(0.16, 1,04)	**0.48**	(0.16, 1,47)	**0.68**	(0.21, 2,25)	
Income									0,684
>€1500	**1,00**		**1,00**		**1,00**		**1,00**		
€1000-€1500	**0.68**	(0.42, 1,11)	**0.74**	(0.45, 1,21)	**0.66**	(0.34, 1,27)	**0.98**	(0.47, 2,06)	
<€1000	**0.44**	(0.26, 0,73)*	**0.49**	(0.28, 0,87)*	**0.55**	(0.29, 1,06)	**0.75**	(0.36, 1,57)	
RII	**0,29**	(0,14, 0,64)*	**0,36**	(0,15, 0,85)*	**0,37**	(0,13, 1,00)	**0,70**	(0,21, 2,31)	0.699
Education level									0,365
Superior BAC	**1,00**		**1,00**		**1,00**		**1,00**		
BAC	**0.63**	(0.32, 1,26)	**0.61**	(0.30,1,23)	**2.13**	(0.73, 6,18)	**2.03**	(0.68, 6,02)	
Inferior BAC	**0.52**	(0.32, 0,86)*	**0.55**	(0.33, 0,91)*	**0.91**	(0.48, 1,73)	**0.98**	(0.50, 1,93)	
RII	**0,36**	(0,16, 0,79)*	**0,40**	(0,18, 0,90)*	**0,62**	(0,21, 1,81)	**0,73**	(0,23, 2,24)	0.407
Employment									0,742
Employed	**1,00**		**1,00**		**1,00**		**1,00**		
Unemployed	**0.61**	(0.23, 1,62)	**0.60**	(0.23, 1,60)	**0.65**	(0.19, 2,20)	**0.70**	(0.19, 2,50)	
Inactive	**0.68**	(0.46, 1,01)	**0.77**	(0.51, 1,15)	**0.81**	(0.49, 1,36)	**0.84**	(0.49, 1,45)	
Complementary health insurance									0,872
Yes	**1,00**		**1,00**		**1,00**		**1,00**		
No	**0.36**	(0.16, 0,81)*	**0.41**	(0.18, 0,95)	**0.48**	(0.22, 1,06)	**0.60**	(0.25, 1,43)	
Basic health insurance									0,111
Yes	**0.80**	(0.41, 1,54)*	**0.82**	(0.42, 1,59)	**0.30**	(0.15, 0,58)*	**0.39**	(0.19, 0,81)*	
No	**1,00**		**1,00**		**1,00**		**1,00**		

*p<0.05, **p<0.001.

[†]Adjusted on the covariates: region, alcohol consumption, smoking status, close relative with cancer & living in couple

[‡]Calculated by the interaction term for the change in Adjusted OR and Adjusted RII between 2005 and 2010

Table 4. Association between socio-economic variables and the probability of cervical smear participation in 2005 and 2010: unadjusted[†] and adjusted Odds Ratios

	Cervical smear 2005 (n=1571)				Cervical smear 2010 (n=1514)				
Socio-economic variable	**Unadjusted**		**Adjusted**		**Unadjusted**		**Adjusted**		***p*-trend[‡] 2005-2010**
	OR	(95% CI)	**OR**	(95 % CI)	**OR**	(95% CI)	**OR**	(95% CI)	
Occupation									0,480
Manager	**1,00**		**1.0**		**1,00**		**1.0**		
Farmer	**0.54**	(0.20, 1,45)	**0.55**	(0.20, 1,52)	**0.79**	(0.19, 3,29)	**0.78**	(0.18, 3,35)	
Self-employed	**0.43**	(0.20, 0,90)*	**0.41**	(0.19, 0,88)*	**0.68**	(0.31, 1,50)	**0.68**	(0.30, 1,52)	
Professional	**0.94**	(0.57, 1,54)	**0.97**	(0.59, 1,61)	**1.43**	(0.89, 2,45)	**1.52**	(0.88, 2,62)	
Employee	**0.62**	(0.40, 0,96)*	**0.65**	(0.41, 1,02)	**0.85**	(0.52, 1,37)	**0.89**	(0.54, 1,44)	
Manual worker	**0.52**	(0.29, 0,92)*	**0.50**	(0.28, 0,91)*	**0.58**	(0.33, 1,01)	**0.68**	(0.37, 1,22)	
Other	**0.75**	(0.38, 1,49)	**0.78**	(0.39, 1,58)	**0.33**	(0.18, 0,60)*	**0.49**	(0.25, 0,94)*	
Income									0,339
>€1500	**1,00**		**1,00**		**1,00**		**1,0**		
€1000-1500	**0.46**	(0.32, 0,65)**	**0.53**	(0.37, 0,77)**	**0.66**	(0.43, 1,01)	**0.76**	(0.48, 1,21)	
<€1000	**0.32**	(0.21, 0,49)**	**0.43**	(0.27, 0,68)**	**0.33**	(0.22, 0,49)**	**0.43**	(0.27, 0,69)**	
RII	**0,16**	(0,09, 0,28)**	**0,24**	(0,13, 0,46)**	**0,20**	(0,11, 0,37)**	**0,28**	(0,14, 0,57)**	0.268
Education level									0,822
Superior BAC	**1,00**		**1,00**		**1,00**		**1,0**		
BAC	**0.95**	(0.63, 1,45)	**1.00**	(0.66, 1,54)	**0.97**	(0.59, 1,58)	**0.93**	(0.57, 1,53)	
Inferior BAC	**0.57**	(0.41, 0,77)**	**0.56**	(0.41, 0,78)**	**0.51**	(0.35, 0,73)**	**0.53**	(0.36, 0,77)**	
RII	**0,36**	(0,21, 0,61)**	**0,35**	(0,2, 0,60)**	**0,28**	(0,16, 0,51)**	**0,3**	(0,16, 0,54)**	0.887
Employment									0,349
Employed	**1,00**		**1,00**		**1,00**		**1,0**		
Unemployed	**0.38**	(0.23, 0,61)**	**0.46**	(0.28, 0,75)*	**0.42**	(0.26, 0,67)**	**0.51**	(0.31, 0,83)*	
Inactive	**0.52**	(0.38, 0,71)**	**0.50**	(0.36, 0,69)**	**0.38**	(0.28, 0,52)**	**0.40**	(0.29, 0,55)**	
Complementary health insurance									0,010
Yes	**1,00**		**1,00**		**1,00**		**1,0**		
No	**0.25**	(0.15, 0,40)**	**0.29**	(0.17, 0,49)**	**0.54**	(0.34, 0,88)*	**0.69**	(0.41, 1,17)	
Basic health insurance									0,524
Yes	**0.46**	(0.29, 0,74)*	**0.57**	(0.35, 0,92)*	**0.42**	(0.28, 0,65)**	**0.59**	(0.36, 0,95)*	
No	**1,00**		**1,00**		**1,00**		**1,00**		

*p<0.05, **p<0.001.

[†] Adjusted on the covariates: region, alcohol consumption, smoking status, close relative with cancer & living in couple

[‡] Calculated by the interaction term for the change in Adjusted OR and Adjusted RII between 2005 and 2010

Table 5. Association between socio-economic variables and the probability of FOBT participation in 2005 and 2010: unadjusted[†] and adjusted Odds Ratios

	FOBT 2005 (n=1222)				FOBT 2010 (n=1425)				
Socio-economic variable	**Unadjusted OR**	(95% CI)	**Adjusted OR**	(95% CI)	**Unadjusted OR**	(95% CI)	**Adjusted OR**	95% CI	***p*-trend[‡] 2005-2010**
Occupation									0,301
Manager	**1,00**		**1.0**		**1,00**		**1.0**		
Farmer	**0.57**	(0.29, 1,10)	**0.66**	(0.34, 1,31)	**0.97**	(0.46, 2,05)	**0.78**	(0.35, 1,73)	
Self-employed	**0.78**	(0.46, 1,31)	**0.74**	(0.43, 1,27)	**0.82**	(0.51, 1,31)	**0.82**	(0.50, 1,35)	
Professional	**0.83**	(0.57, 1,23)	**0.88**	(0.59, 1,30)	**0.85**	(0.60, 1,20)	**0.91**	(0.63, 1,31)	
Employee	**0.66**	(0.45, 0,96)*	**0.79**	(0.53, 1,17)	**0.78**	(0.54, 1,12)	**0.96**	(0.64, 1,44)	
Manual worker	**0.67**	(0.44, 1,03)	**0.68**	(0.44, 1,05)	**0.66**	(0.45, 0,96)*	**0.63**	(0.42, 0,95)*	
Other	**0.76**	(0.39, 1,46)	**0.94**	(0.47, 1,89)	**0.58**	(0.36, 0,95)*	**0.60**	(0.35, 1,02)	
Income									0,253
>€1500	**1,00**		**1,00**		**1,00**		**1,00**		
€1000-1500	**0.85**	(0.61, 1,18)	**0.93**	(0.66, 1,31)	**0.94**	(0.67, 1,31)	**1.11**	(0.77, 1,61)	
<€1000	**0.63**	(0.42, 0,94)*	**0.74**	(0.48, 1,15)	**0.89**	(0.62, 1,29)	**1.13**	(0.74, 1,72)	
RII	**0,54**	(0,31, 0,93)*	**0,70**	(0,38, 1,28)	**0,83**	(0,49, 1,41)	**0,80**	(0,43, 1,48)	0.275
Education level									0,485
Superior BAC	**1,00**		**1,00**		**1,00**		**1,00**		
BAC	**0.79**	(0.50, 1,24)	**0.85**	(0.54, 1,33)	**1.21**	(0.81, 1,83)	**1.27**	(0.82, 1,97)	
Inferior BAC	**0.77**	(0.58, 1,04)	**0.79**	(0.59, 1,07)	**0.99**	(0.74, 1,34)	**0.99**	(0.72, 1,36)	
RII	**0,67**	(0,41, 1,09)	**0,69**	(0,42, 1,14)	**0,90**	(0,56, 1,45)	**1,14**	(0,68, 1,36)	0.519
Employment									0,960
Employed	**1,00**		**1,00**		**1,00**		**1,00**		
Unemployed	**0.86**	(0.40, 1,88)	**1.08**	(0.49, 2,38	**0.68**	(0.37, 1,27)	**0.87**	(0.45, 1,68)	
Inactive	**1.45**	(1.12, 1,88)*	**1.56**	(1.19, 2,03)*	**1.58**	(1.25, 1,99)**	**1.52**	(1.18, 1,96)*	
Complementary health insurance									0,441
Yes	**1,00**		**1,00**		**1,00**		**1,00**		
No	**0.50**	(0.25, 0,97)*	**0.52**	(0.26, 1,04)	**0.65**	(0.40, 1,05)	**0.85**	(0.50, 1,45)	
Basic Health insurance									0,257
Yes	**0.70**	(0.43, 1,16)	**0.72**	(0.45, 1,16)	**1.03**	(0.69, 1,54)	**1.11**	(0.71, 1,72)	
No	**1,00**		**1,00**		**1,00**		**1,00**		

*p<0.05, **p<0.001.

[†]Adjusted on the covariates: region, alcohol consumption, smoking status, close relative with cancer & living in couple

[‡]Calculated by the interaction term for the change in Adjusted OR and Adjusted RII between 2005 and 2010

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found**: Included, please see page 1 and 2.**
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported **Included, please see 5 and 6**
Objectives	3	State specific objectives, including any prespecified hypotheses**. Included please see page 6, last sentence.**
Methods		
Study design	4	Present key elements of study design early in the paper. **Included, please see page 7, study population section, first paragraph.**
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection. **Included, please see page 7, study population section, second paragraph.**
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants**. Included, please see page 7, study population section, first paragraph.**
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable**. Included, please see page 8, Measures section.**
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group. **Included, please see page 8, Measures section.**
Bias	9	Describe any efforts to address potential sources of bias. **Included, please see page 7, second sentence, study population section, and page 8, last paragraph, Measures section.**
Study size	10	Explain how the study size was arrived at**. Included, please page 7, second paragraph, study population section.**
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why**. Included, please page 8, Measures sections.**
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding **Included, please page Statistical Analysis section pages 9-10**
		(*b*) Describe any methods used to examine subgroups and interactions **Included,**

	please statistical analysis section, second and third paragraphs.
(*c*) Explain how missing data were addressed. **Included, please see page 7, study population section, second paragraph.**	
(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy**. Included, please see page 8, Measures section, last paragraph.**	
(*e*) Describe any sensitivity analyses. **N/A.**	

Continued on next page

Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed **YES**
		(b) Give reasons for non-participation at each stage **YES**
		(c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders **YES**
		(b) Indicate number of participants with missing data for each variable of interest **YES**
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures **YES**
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included **YES**
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period **YES**
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results	18	Summarise key results with reference to study objectives **YES**
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias **YES**
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence **YES**
Generalisability	21	Discuss the generalisability (external validity) of the study results **YES**
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based **YES**

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Temporal trend in socio-economic inequalities in the uptake of cancer screening programs in France between 2005 and 2010: Results from the Cancer Barometer Surveys

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Temporal trend in socio-economic inequalities in the uptake of cancer screening programs in France between 2005 and 2010: Results from the Cancer Barometer Surveys

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ABSTRACT

Objectives: Cancer screening is a form of secondary prevention for a disease which is now the leading cause of death in France. Various socio-economic indicators have been identified as potential factors for disparities in breast, cervical and colorectal cancer screening uptake. We aimed to identify the socio-economic inequalities which persisted in screening uptake for these cancers, and to quantify these disparities over a 5-year period.

Setting: The Cancer-Barometer was a population-based survey carried out in 2005 and 2010 in Metropolitan France.

Participants: A randomly selected sample of participants aged 15 to 85 years, n=3820 in 2005 and n=3727 in 2010, were interviewed on their participation in breast, cervical and colorectal cancer screening programs and their socio-economic profile.

Primary and secondary outcome measures: For each type of screening-program, we calculated participation rates, odds ratios (OR) and relative inequality indices (RII) for participation, derived from logistic regression of the following socio-economic variables: income, education, occupation, employment and health insurance. Changes in participation between 2005 and 2010 were then analyzed.

Results: Participation rates for breast and colorectal screening increased significantly along the majority of socio-economic categories, whereas for cervical screening there were no significant changes between 2005 and 2010. RIIs for income remained significant for cervical smear in 2005 (RII=0.25, 95% CI 0.13-0.48) and in 2010 (RII=0.31, 95% CI 0.15-0.64). RIIs for education in mammography (RII=0.43, 95% CI 0.19-0.98) and cervical smear (RII=0.36, 95% CI 0.21-0.64) were significant in 2005 and remained significant for cervical smear (RII=0.40, 95% CI 0.22-0.74) in 2010.

Conclusions: There was a persistence of socio-economic inequalities in uptake of opportunistic cervical cancer screening. Conversely, organized screening-programs for breast and colorectal cancer saw a reduction in relative socio-economic inequalities, even though the results did not reach statistical significance. The findings suggest that organized cancer screening programs have the potential to reduce socio-economic disparities in participation.

Key words: cancer screening, breast cancer, cervical cancer, social inequalities, cancer epidemiology

Strengths and limitations of this study

- First study to examine temporal changes in inequalities for cancer screening uptake in France using relative inequality index.
- Benefits from datasets of two identical questionnaires on cancer screening uptake, taken 5 years apart, using two comparable population samples, hence minimizing information bias.
- Evolution in the format of colorectal screening program in terms of technique and age limits may have led to measured differences in uptake between 2005 and 2010.
- Residents of nursing homes and other medical institutions without a personal telephone line were excluded from the survey, limiting the generalizability of the findings.
- Relatively small number for certain socio-economic strata, reducing therefore the precision of some estimates.

INTRODUCTION

Screening for cancer is an important form of secondary prevention for a disease which is now leading cause of death in France and worldwide [1]. The 2008 European report on cancer recommends that health systems focus their resources on cancer prevention and early detection rather than treatment alone, as the global disease burden of cancer threatens to become unsustainable in terms of financial costs, pressure on services, follow-up of patients and delivery of care [2].

To date, many European countries have rolled out screening programs for breast, colorectal and cervical cancer via mammography, faecal occult blood test (FOBT) and cervical smear respectively [3, 4]. However, for these screening programs to have a significant effect on reducing cancer mortality, they require a minimum level of participation among the eligible population; for instance 70% for mammography, and 50% for FOBT [5].

We reviewed several publications from France, UK, USA, Italy, Denmark, Korea and Argentina, which identified variables shown to have a significant effect on cancer screening uptake [6-19]. For breast cancer screening, various different social and economic variables were found to have a positive effect on uptake, including employment, living in a couple, higher occupation class, higher education level, income, private health insurance, car/home ownership and rural residency. However, no single variable was consistently observed across studies except for participation in other screening programs [7, 18]. For cervical cancer screening, the variables identified as having a significant positive effect on uptake were more numerous, and notably consistent for income [7, 11, 17], higher education level [10-12, 17, 18], employment [6, 12, 18, 19] and private health insurance [6, 7, 18]. For colorectal screening, general practitioners' (GP) consultation [6, 7, 18, 19] was consistently shown to have a significant positive effect on uptake of screening across the studies, as

well as income [14, 16, 18]. However, it remains unclear whether the effect of these socio-economic variables on participation rates in screening programs persists over time.

Only one study drawn from the 2006, 2008 and 2010 French Healthcare and Health Insurance surveys has examined the temporal evolution in breast, cervical and colorectal cancer screening uptake along socio-economic strata in France to date [6]. This study conducted among 10 000 participants found that those classified as unskilled workers were less likely to have undergone cervical cancer screening (OR = 1.64 [1.38-1.95]). The results also showed that women without (OR = 2.05 [1.68-2.51]) or receiving free complementary health insurance (OR = 1.79 [1.36-2.37]) were less likely to have undergone breast cancer screening. In this study, the authors found that inequalities for participation in breast and colorectal cancer screening persisted over the study period from 2006 to 2010 [6]. Thus, we believe that there is a need to re-examine how these trends may have evolved with respect to expansion in the coverage and awareness of organized cancer screening programs. The third French National Cancer Plan for the 2014-2019 period has identified early detection of cancers as a primary priority [20]. Within this goal is the reduction of inequalities associated with cancer diagnosis, with the hope that it subsequently reduces mortality rates. Any widening or reduction in socio-economic inequalities in the uptake of screening programs that are identified may then be used to direct future policy of the French national cancer control plan, which specifically seeks to address this issue [20]. We aim therefore in the present study to identify the socio-economic inequalities which persist for uptake of breast, cervical and colorectal cancer screening, and to quantify these disparities over a 5 year period in France.

MATERIALS AND METHODS

Study population

We used data, obtained by formal permission, from the Cancer Barometer surveys, two telephone surveys on cancer-related knowledge, attitudes and practices conducted by the French National Institute for Prevention and Health (now part of Santé Publique France). Both surveys were carried out on a representative random sample of the general French population aged over 16 years old for the 2005 survey and aged 15–85 years old for the 2010 survey. A two-stage random sampling design was used. Residents of nursing homes or other medical institutions who did not possess a personal telephone line were not included in the samples. Private households with telephones were included in the sample. The first sampling step was household selection (by phone number). Within each selected household, one French speaking person aged 15–85 was randomly selected using the "next birthday" method. The interviews were conducted using a computer-assisted telephone interview (CATI) system.

In order to obtain adequate statistical power for measuring associations between variables and changes in participation rates along smaller levels, a sample size of between 3500 and 4000 was deemed appropriate. The 2005 Cancer Barometer sample was comprised of 4046 participants aged over 16 years interviewed between April and June 2005 [18]. There were 226 individuals with missing observations in the 2005 Cancer Barometer sample, notably for all 3 of the dependent variables, and 7 out of 10 of the covariates and independent variables. These individuals terminated the survey prematurely, and were thus removed from the analysis as their data was non-contributive, leaving 3820 participants in the sample population. Females (51.5%) responded more often than males (48.5%) and mean age of interviewees was 46.7 years. The 2010 Cancer Barometer sample was comprised of 3727 participants aged 15 to 85 interviewed during the first semester of 2010 [19]. The mean age was 44.6 years and the majority of participants were also

female (52.0%vs. 48.0%). The response rates for the 2005 and 2010 Cancer Barometers were 51.2% and 47.0%, respectively.

Measures

Socio-economic indicators (independent variables) were as follows: education level (inferior, equal to or superior to Baccalauréat (high-school diploma), employment status (employed, unemployed, and inactive), occupational class (farmer, trader, manager, professional, employee, manual worker, other), monthly income (below €1000, €1000-1500, above €1500) and health insurance (complementary vs. basic insurance coverage). The outcome variables were participation in breast, cervical and colorectal cancer screening programs (dependent variables). For breast cancer screening, participants aged over 40 years were asked if they had undergone mammography within the previous 2 years. For cervical cancer screening, participants aged over 20 years were asked if they had undergone a cervical smear within the previous 3 years. For colorectal cancer screening, participants aged 50-74 years were asked if they had undergone a faecal occult blood test (FOBT) within their lifetime. Covariates included gender, age, smoking status, alcohol consumption, region, living in a couple and having a close relative with cancer. For the calculation of screening participation rates, we added filters to select the target population eligible for each of the 3 different screening programs. Breast screening by mammography (n=1546): female gender and 49<age<75. Cervical screening by cervical smear (n=3085): female gender and 24<age<66. Colorectal screening by FOBT (n=2647): both genders where 49<age<75.

The weighting was based on the data of the 1999 and 2008 Employment Survey of the French population [21], taking into account age, gender, region, education level and number of persons per household [18]. This allowed us to effectively calculate age-adjusted standardized rates for

screening participation, in addition to later adjusting the regression models on the covariates mentioned.

Statistical analysis

We calculated age-adjusted screening rates (AAR) for each stratum using the weighting provided by the INPES. The temporal evolution in the participation rate along each stratum between 2005 and 2010 was examined by adding an interaction term with the year of the survey. The disparity within each socio-economic variable was calculated as the absolute difference between the AAR for the highest and lowest group within an ordinal or binary variable for the given year.

Odds ratios (OR) derived from multiple logistic regression of screening participation on each socio-economic variable separately were used as a measure of participation likelihood for each stratum of the 6 socio-economic variables. The model was adjusted on the covariates: age, gender (colorectal screening only), region, alcohol, smoking, living in couple and close relative with cancer. For categorical variables, the higher socio-economic position was used as the reference group. The p-value for significance of the evolution of the odds ratios between 2005 and 2010 was calculated using an interaction term between the socio-economic variable and the time period, in order to be consistent with the methodology of previous studies on the topic [22, 23].

For ordinal variables of income and education level, we calculated the Relative Inequality Index (RII) as a measure of health inequality as described by Mackenbach and Kunst [24]. Previous studies on health inequalities, including breast cancer screening uptake [4, 9], employed a similar methodology for examining temporal evolutions along ordered socio-economic strata [23, 25]. The RII is a regression-based measure that summarizes the association between two variables. It is computed by ranking income and education values on a scale from the lowest, which is 0, to the highest, which is 1. Each income or education level value covers a range on this scale that is

proportional to the number of participants who held that value and is given a new value on the scale corresponding to the cumulative midpoint of its range. The RII resembles relative risk in that it compares the probability of cancer screening uptake at the extremes of income and educational levels, but is estimated using the data on all income and education values and is weighted to account for the distribution of these values. Here the RII was fitted using logistic regression models. An RII of 0.5 for example implies that participants in the most deprived group (those with lower incomes and educations levels) had a 50% lower probability of cancer screening uptake when compared to those in the least deprived group (those with higher incomes and education levels). All statistical analysis was performed using SAS version 9.2.

RESULTS

Table 1 presents the demographic and socio-economic characteristics of the study populations. The overall participation rates among the eligible populations for breast, cervical and colorectal cancer screenings are shown in Table 2. Chi-squared tests for the change in participation rates along each socio-economic stratum between 2005 and 2010 are also included. For mammography, participation rates increased significantly ($p<0.05$) along all socio-economic strata, with the exception of farmers, managers, manual workers, unemployed, those with basic health insurance and education level superior to Baccalauréat. For FOBT, participation rates increased significantly along all socio-economic strata between 2005 and 2010, with the exception of those unemployed or occupation classified as other. For cervical smear there were no significant changes in participation rates along any of the socio-economic strata, except for those without complementary health insurance, which increased significantly from 52.51% to 71.0% ($p=0.017$).

Table 3 shows the results of the logistic regression models for mammography participation on each socio-economic variable separately, adjusted for covariates. In 2005, farmers, self-employed,

employees and manual workers showed significantly reduced participation compared to managers/executives, whereas in 2010 only the association in manual workers remained significant. In 2005, those with an education level inferior to Baccalauréat (OR=0.57, 0.35-0.95) showed significantly reduced participation compared to those superior to Baccalauréat, which became non-significant in 2010 (OR=1.04, 0.53-2.05).

Table 4 shows the results of the regression model for cervical smear participation for each socio-economic variable. In 2005, significantly reduced participation was observed for self-employed and manual workers, which became non-significant for both in 2010. In 2005, there was significantly reduced participation for those earning <€1000 and €1000-€1500, which remained significant in 2010 for those earning <€1000 (OR=0.47, 95% CI 0.29-0.76). An education level inferior to Baccalauréat showed significantly lower participation in both 2005 and in 2010. In 2005, being unemployed or inactive significantly reduced participation, and remained significant for both in 2010. The odds ratio for cervical smear participation changed significantly (p=0.014) for those without complementary health insurance from 0.29 (95% CI 0.17-0.49) in 2005 to 0.64 (95% CI 0.38-1.08) in 2010. Having only basic health insurance was significantly associated with reduced participation in both periods.

Table 5 shows the logistic regression results for FOBT participation on each socio-economic variable. For occupation, manual workers (OR=0.63, 95% CI 0.42-0.96) showed significantly reduced participation in 2010. Odds ratios for all other occupations showed reduced participation compared to managers, but at a non-significant level in 2005 and 2010. Those earning <€1000 showed reduced participation in 2005 (OR=0.62, 95% CI 0.32-0.97), which became non-significant in 2010. There were no significant temporal changes in any of the odds ratios for participation in breast or colorectal cancer screening between 2005 and 2010.

The regression of screening participation on income distribution produced RIIs which can be found in Tables 3-5. The results showed significant inequalities for cervical smear (RII=0.25, 95% CI 0.13-0.48) in 2005, but not for mammography (RII=0.47, 95% CI 0.19-1.29) or FOBT (RII= 0.70, 95% CI 0.38-1.28). In 2010 the income-based RII remained significant for cervical smear (RII=0.31, 0.15-0.64). For education, mammography (RII=0.43, 95% CI 0.19-0.98) and cervical smear (RII=0.36, 95% CI 0.21-0.64) showed significant inequalities in 2005, whereas the RII for FOBT was non-significant (RII=0.69, 95% CI 0.42-1.14). In 2010, the education-based RII for mammography became non-significant (RII=0.80, 95% CI 0.26-2.50), whereas the RII for cervical smear remained significant (RII=0.40, 95% CI 0.22-0.74). The p-trend for the temporal change in the RIIs (adjusted model) measured by interaction term between 2005 and 2010, was non-significant for all 3 screening programs for income and education level.

DISCUSSION

Our objective was to identify the socio-economic inequalities which persisted for uptake of breast, cervical and colorectal cancer screening, and to quantify these disparities between the 2005 and 2010. In absolute terms, we found a significant increase in participation rates across all socio-economic strata for mammography and for FOBT between 2005 and 2010. Cervical cancer screening however saw no significant change in participation rates between 2005 and 2010 (except for those without complementary health insurance). A similar trend was observed when relative inequalities were considered. It should be noted that some of these inequalities were persistent between 2005 and 2010, even though formal statistical tests for trend were generally not significant.

Findings in the context of the literature

It is encouraging to note the significant increase in participation rates across all socio-economic strata for mammography between 2005 and 2010. This effect was not demonstrated in a French study by Sicsic et al. in 2006, 2008 and 2010, which showed a decrease in mammography participation rates over time [6]. This study did however show a large increase in colorectal cancer screening rates, in line with our findings. Cervical cancer screening however saw no significant change in participation rates between 2005 and 2010 (except for those without complementary health insurance), while Sicsic et al. showed an overall decrease in participation rates from 2006 to 2010. Our study confirmed significantly reduced participation for manual workers in breast and colorectal screening and for those with only basic health insurance in breast and cervical screening in 2010. This is consistent with Sicsic et al., which showed reduced participation in all 3 screening programs for manual workers and those with only basic health insurance.

Several factors may explain why some of our findings differ from those by Sicsic et al. The study by Sicsic et al. was based on three surveys carried out in 2006, 2008 and 2010, with therefore a two-year interval, whereas the Cancer Barometer survey was conducted at two points in time in 2005 and 2010. Another important difference between the two studies relies on their objectives and consequently on the methods used to reach them. The study by Sicsic et al. aimed to analyze the obstacles to and levers for breast, cervical, and colorectal cancer screening uptake and their trends over time, whereas the aim of our study was to identify the socio-economic inequalities which persist for uptake of breast, cervical and colorectal cancer screening, and to quantify these disparities over a 5 year period. Thus, Sicsic et al. pooled their three samples and did not conduct direct comparisons of associations between indicators of socioeconomic position and uptake of cancer screenings between periods.

Breast and colorectal cancer screening programs saw the absolute differences in participation rates reduced over time for all socio-economic variables in our study, with the exception of

employment and basic health insurance. Sicsic et al. found that disparities in participation did not decrease for mammography or FOBT screening from 2006 to 2010 [6]. An American study by Kim et al. showed the disparity in mammography participation based on income remained unchanged, while the disparity based on education decreased from 2000 to 2005 [9]. Cervical cancer screening however saw a persisting disparity in participation rates for the majority of socio-economic variables in our study, consistent with the results of De Maio et al. and Sicsic et al. [6, 17].

The relative inequalities for income and education decreased for breast and colorectal cancer screening in our study, albeit non-significantly. This is somewhat consistent with DeMaio et al., which showed a reduction in the RII for breast cancer screening from 2005 to 2009 [17]. In the study by Kim et al., the income-based relative inequalities tended to decrease slightly, while those for education remained constant over time [9]. The relative inequalities for cervical cancer screening persisted for both income and education from 2005 to 2010 in our study, both remaining statistically significant. This is partially consistent with the De Maio et al., where the social gradient decreased for income and increased for education between 2005 and 2010 [17].

Interpretation of results

Breast and colorectal screening programs are organized at a national level and differences in absolute participation rates and relative inequalities decreased over time for all socio-economic variables. For both breast and colorectal screening, the odds ratios for manual workers showed reduced participation compared to managers/executives in 2010. Education and occupation are strongly correlated, with manual workers having a higher proportion of participants with an educational level inferior to Baccalauréat (85%) than any other occupational category in 2010. Thus they may have been less aware of the health marketing campaigns for colorectal cancer screening and the recommendation for FOBT, due to the negative effect of lower education on health literacy [14, 26, 27].

Cervical cancer remains without a nationally organized screening program in France. It is the duty of doctors to organize and falls to the individual to pay for opportunistic screening via cervical smear test. The lack of a nationally organised screening program may impose significant financial, educational and cultural barriers to screening uptake among certain sections of the French population. The financial costs for a consultation and laboratory processing of the screening test may deter those with only basic health insurance, as public reimbursement covers only 70% of the cost [28]. This may account for the persistence of the observed differences in participation rates and large RIIs. Improving the awareness, affordability and access to cervical cancer screening should be prioritised in order to increase participation rates and reduce socio-economic disparities.

Limitations and strengths of the study

Our study used two almost identical datasets to construct a temporal analysis of participation in screening programs in France between 2005 and 2010. The use of relative inequality indices to measure the evolution of socio-economic inequalities in our study is the first to employ this methodology among a French population for cancer screening. The comparability of the study populations minimized selection bias and the conservation of the questionnaire format minimized information bias.

The study still has several limitations however. It shares the usual shortcomings of phone surveys. There is a potential selection bias, as residents of nursing homes or other medical institutions who did not possess a personal telephone line were not included in the samples. The study includes only those who are French speakers, excluding individuals unable to answer fluently in French. There was no available data on ethnicity or nationality of participants in the study, which may have been an important source of confounding or effect modification. The exclusion of the above subpopulations, which are likely to be more socio-economically disadvantaged, may have overestimated the screening participation rates in our study.

Our study used two separate sample populations, whose distributions in Table 2 differed significantly for all of the socio-economic indicators and several covariates. The difference in sample distributions may have accounted for the observed differences in screening participation.

Changes in screening policies concerning age limits, screening techniques and regional access left the 2005 and 2010 Cancer Barometers not directly comparable for certain programs. The question of screening participation for colorectal cancer was therefore limited to lifetime use of FOBT. Organized cervical screening was available in 13 regions in 2009, a source of regional variation not present in 2005. Some screening techniques are more memorable to patients, due to the invasiveness of the screening technique or the duration of the screening intervals, which may have led to recall bias.

The respective analytical sample sizes in 2005 and 2010 for breast (n=742, n=804), cervical (n=1571, n=1514) and colorectal (n=1222, n=1425) cancer screening may have been too small to capture disparities along socio-economic strata, leading to false observations and conclusions. Missing observations for each variable accounted for less than 5% of the total population, except for the variable income (16.3% missing in 2005 and 9.3% in 2010). This might have limited the precision of certain estimates, producing participation rates with large standard errors and odds ratios with large confidence intervals. We undertook multiple comparisons in our study. Thus, we cannot exclude that some of the results we have observed are due to chance.

Conclusion

The findings suggest that organized cancer screening programs have the potential to reduce socio-economic disparities in participation.

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Competing interest statement

All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf and declare: no support from any organisation for the submitted work; no financial relationships with any organisations that might have an interest in the submitted work in the previous three years; no other relationships or activities that could appear to have influenced the submitted work.

Contributors

HN conceived the study, advised on methodology, reviewed the results of statistical analyses and supervised the final edit of the manuscript. DK reviewed the background literature, run statistical analyses and drafted the manuscript. CE, CL, PA provided advice on methodology and statistical analyses. CL & PA directed the data collection. All authors contributed to the final draft of this manuscript.

Data sharing statement

All data presented in this manuscript came from 2 original datasets of the 2005 and 2010 Cancer Barometer surveys. The original files can be requested by contacting Santé Publique France (formerly INVS and INPES) via Pierre Arvidson (pierre.arwidson@santepubliquefrance.fr) or Christophe Léon (christophe.leon@santepubliquefrance.fr).

Table 1. Standardized distribution of study populations for 2005 and 2010 Cancer Barometer surveys, p-value for Chi-squared test

Variables	Barometer 2005 (n=3820)		Barometer 2010 (n=3727)		p-value
	n	%	n	%	
Gender					0.660
Male	1854	48,5	1790	48,0	
Female	1966	51,5	1937	52,0	
Region					0.976
Ile-de-France	701	18,4	696	18,7	
West Paris basin	380	10,0	348	9,3	
East Paris basin	305	8,0	290	7,8	
North	257	6,7	238	6,4	
West	508	13,3	504	13,5	
East	334	8,8	321	8,6	
South West	414	10,9	412	11,1	
South East	455	12,0	447	12,0	
Mediterranée	457	12,0	471	12,6	
Occupation					<0.001
Farmer	117	3,1	81	2,2	
Self-employed/craftsman	220	5,8	270	7,2	
Manager/executive	589	15,4	595	16,0	
Professional	773	20,3	914	24,5	
Employee/office worker	970	25,4	829	22,3	
Manual worker	642	16,8	839	22,5	
Oher	506	13,3	199	5,3	
Education level					<0.001
Inferior BAC*	1946	52,0	2270	61,2	
BAC	651	17,4	635	17,1	
Superior BAC	1146	30,6	803	21,7	
Monthly Income					<0.001
<€1000	414	13,2	399	12,1	
€1000-1500	663	21,0	499	15,1	
>€1500	2075	65,8	2401	72,8	
Employment					<0.001
Employed	2146	56,2	1851	49,7	
Unemployed	177	4,6	260	7,0	
Inactive	1497	39,2	1615	43,3	
Alcohol consumption					<0.001
Yes	3430	89,8	3195	85,7	
No	389	10,2	532	14,3	
Smoking status					<0.001
Yes	964	25,2	1195	32,1	
No	2856	74,8	2532	67,9	
Close Relative with cancer					0.950
Yes	2366	62,1	2198	62,1	
No	1446	37,9	1339	37,9	
Living in couple					0.071
Yes	2465	64,6	2333	62,6	
No	1351	35,4	1394	37,4	
Complementary Health Insurance					<0.001
Yes	3518	92,6	3210	89,6	
No	282	7,4	375	10,5	
Basic Health Insurance					0.003
Yes	361	10,2	441	12,4	
No	3182	89,8	3109	87,6	

* BAC = Baccalauréat (high-school diploma)

Table 2. Standardised† participation rates for eligible participants in 3 screening programs, Chi-squared test for 2005-2010, *p*-trend

Socio-economic variable	Mammography			Cervical smear			FOBT		
	participation rate (%) ± SE			participation rate (%) ± SE			participation rate (%) ± SE		
	2005 (n=742)	2010 (n=804)	Chi2 *p*-value	2005 (n=1571)	2010 (n=1514)	Chi2 *p*-value	2005 (n=1222)	2010 (n=1425)	Chi2 *p*-value
Overall	88.0	88.3		79.7	81.4		34.0	51.6	
Occupation									
Farmer	62.49 ±8.24	87.64 ±8.81	0.148	75.61 ±7.28	80.39 ±11.63	0.739	26.97 ±6.69	56.50 ±10.82	0.006
Self-employed	63.70 ±9.46	85.96 ±5.37	0.027	71.02 ±7.00	77.92 ±6.89	0.438	33.47 ±5.61	52.30 ±5.75	0.009
Manager	85.50 ±4.04	91.45 ±2.50	0.262	85.15 ±2.51	83.88 ±3.05	0.740	39.33 ±3.89	57.33 ±3.31	0.0003
Professional	74.87 ±3.74	87.82 ±2.95	0.004	84.31 ±1.95	88.17 ±1.68	0.153	35.04 ±3.21	53.32 ±2.79	<0,0001
Employee	68.76 ±3.00	90.58 ±1.98	<0.0001	78.05 ±1.81	81.52 ±2.06	0.170	29.92 ±2.63	51.07 ±3.54	<0,0001
Manual worker	64.52 ±6.01	76.02 ±5.29	0.161	74.70 ±3.96	75.00 ±4.22	0.956	30.29 ±3.74	46.95 ±4,23	0.001
Other	69.37 ±6.19	83.70 ±5.28	0.097	81.14 ±4.21	62.94 ±6.53	0.010	32.87 ±6.20	43.84 ±6.92	0.204
Education level									
Inferior BAC	67.80 ±2.29	86.26 ±1.79	<0.0001	75.20 ±1.77	76.88 ±1.97	0.484	31.55 ±1.82	51.06 ±2.06	0
BAC	71.86 ±5.71	93.63 ±2.15	0.0003	83.59 ±2.47	86.42 ±2.03	0.385	32.07 ±4.46	56.06 ±3.58	<0,0001
Superior BAC	80.17 ±3.49	87.34 ±2.56	0.153	84.27 ±1.65	86.81 ±1.67	0.318	37.39 ±3.27	51.23 ±2.92	0.002
Difference	*12.37*	*1.08*		*9.07*	*9.93*		*5.84*	*0.17*	
Income									
<€1000	58.45 ±4.48	82.62 ±3.92	0.001	64.78 ±4.01	64.81 ±4.70	1	27.02 ±3.55	49.40 ±4.79	0.0001
€1000-1500	68.62 ±4.19	84.95 ±3.57	0.006	72.43 ±2.96	78.81 ±3.49	0.161	33.29 ±3.35	50.61 ±4.33	0.001
>€1500	76.21 ±2.65	89.57 ±1.59	<0.0001	85.21 ±1.25	84.96 ±1.36	0.885	37.07 ±2.23	52.29 ±1.96	<0,0001
difference	*17.76*	*6.95*		*20.43*	*20.15*		*10.05*	*2.89*	
Complementary health insurance									
Yes	72.09 ±1.84	88.08 ±1.38	<0.0001	81.77 ±1.08	81.83 ±1.29	0.964	33.63 ±1.53	52.31 ± 1.64	<0,0001
No	48.35 ±9.53	78.06 ±7.49	0.013	52.51 ±6.04	71.00 ±5.67	0.017	20.10 ±5.58	41.51 ±7.71	0.011
difference	*23.76*	*10.02*		*29.26*	*10.83*		*13.53*	*10.80*	
Basic health insurance									
Yes	66.12 ±7.38	69.98 ±8.60	0.694	67.20 ±4.70	67.22 ±5.47	1	26.23 ±4.56	52.75 ±6.93	0.0001
No	70.99 ±1.93	88.72 ±1.28	<0.0001	81.52 ±1.12	82.87 ±1.24	0.399	33.83 ±1.60	52.06 ±1.64	<0,0001
difference	*4.87*	*18.74*		*14.32*	*15.65*		*7.60*	*0.69*	
Employment									
Employed	76.23 ±3.07	89.0 ±2.21	0.001	83.75 ±1.21	86.56 ±1.34	0.097	28.37 ±2.42	45.11 ±2.56	<0,0001
Unemployed	66.26 ±9.44	84.1 ±8.73	0.176	66.00 ±5.25	72.88 ±5.23	0.304	25.48 ±6.60	35.91 ± 9.21	0.308
Inactive	68.58 ±2.32	86.79 ±1.75	<0.0001	72.72 ±2.51	71.15 ±2.73	0.665	36.51 ±1.93	56.48 ±2.03	<0,0001

†Weighted by age, gender, region and educational level according to standard population of the 1999 and 2008 Employment Surveys (INSEE)

Table 3. Association between socio-economic variables and the probability of participation in mammography in 2005 and 2010: unadjusted[†] and adjusted Odds Ratios

	Mammography 2005 (n=742)				Mammography 2010 (n=804)				
Socio-economic	**Unadjusted**		**Adjusted**		**Unadjusted**		**Adjusted**		***p*-trend[‡]**
variable	**OR**	(95% CI)	**OR**	(95% CI)	**OR**	(95% CI)	**OR**	(95 % CI)	**2005-2010**
Occupation									0.521
Manager	**1.00**		**1.0**		**1.00**		**1.0**		
Farmer	**0.28**	(0.10, 0.77)*	**0.33**	(0.12, 0.92)*	**0.66**	(0.08, 5.45)	**0.64**	(0.07, 5.54)	
Self-employed	**0.30**	(0.11, 0.81)*	**0.33**	(0.12, 0.93)*	**0.57**	(0.18, 1.86)	**0.60**	(0.18, 2.00)	
Professional	**0.51**	(0.23, 1.10)	**0.53**	(0.24, 1.18)	**0.67**	(0.26, 1.72)	**0.66**	(0.25, 1.74)	
Employee	**0.37**	(0.18, 0.77)*	**0.39**	(0.19, 0.82)*	**0.90**	(0.36, 2.26)	**1.13**	(0.43, 2.95)	
Manual worker	**0.31**	(0.13, 0.74)*	**0.34**	(0.14, 0.84)*	**0.30**	(0.11, 0.78)*	**0.34**	(0.12, 0.94)*	
Other	**0.38**	(0.16, 0.95)*	**0.45**	(0.17, 1.14)	**0.48**	(0.16, 1.47)	**0.59**	(0.18, 1.95)	
Income									0.775
>€1500	**1.00**		**1.00**		**1.00**		**1.00**		
€1000-€1500	**0.68**	(0.42, 1.11)	**0.83**	(0.50, 1.39)	**0.66**	(0.34, 1.27)	**1.04**	(0.49, 2.20)	
<€1000	**0.44**	(0.26, 0.73)*	**0.57**	(0.32, 1.03)	**0.55**	(0.29, 1.06)	**0.80**	(0.38, 1.68)	
RII	**0.29**	(0.14, 0.64)*	**0.47**	(0.19, 1.29)	**0.37**	(0.13, 1.00)	**0.78**	(0.23, 2.64)	0.781
Education level									0.403
Superior BAC	**1.00**		**1.00**		**1.00**		**1.00**		
BAC	**0.63**	(0.32, 1.26)	**0.61**	(0.30, 1.23)	**2.13**	(0.73, 6.18)	**2.09**	(0.70, 6.22)	
Inferior BAC	**0.52**	(0.32, 0.86)*	**0.57**	(0.35, 0.95)*	**0.91**	(0.48, 1.73)	**1.04**	(0.53, 2.05)	
RII	**0.36**	(0.16, 0.79)*	**0.43**	(0.19, 0.98)*	**0.62**	(0.21, 1.81)	**0.80**	(0.26, 2.50)	0.450
Employment									0.786
Employed	**1.00**		**1.00**		**1.00**		**1.00**		
Unemployed	**0.61**	(0.23, 1.62)	**0.60**	(0.23, 1.61)	**0.65**	(0.19, 2.20)	**0.74**	(0.21, 2.68)	
Inactive	**0.68**	(0.46, 1.01)	**0.93**	(0.57, 1.54)	**0.81**	(0.49, 1.36)	**1.30**	(0.65, 2.60)	
Complementary health insurance									0.859
Yes	**1.00**		**1.00**		**1.00**		**1.00**		
No	**0.36**	(0.16, 0.81)*	**0.41**	(0.18, 0.95)*	**0.48**	(0.22, 1.06)	**0.60**	(0.26, 1.42)	
Basic health insurance									0.121
Yes	**0.80**	(0.41, 1.54)*	**0.83**	(0.43, 1.61)	**0.30**	(0.15, 0.58)*	**0.41**	(0.20, 0.85)*	
No	**1.00**		**1.00**		**1.00**		**1.00**		

*p<0.05, **p<0.001.

[†]Adjusted on the covariates: age, region, alcohol consumption, smoking status, close relative with cancer & living in couple

[‡]Calculated by the interaction term for the change in Adjusted OR and Adjusted RII between 2005 and 2010

Table 4. Association between socio-economic variables and the probability of cervical smear participation in 2005 and 2010: unadjusted[†] and adjusted Odds Ratios

	Cervical smear 2005 (n=1571)				Cervical smear 2010 (n=1514)				
Socio-economic	**Unadjusted**		**Adjusted**		**Unadjusted**		**Adjusted**		***p*-trend[‡]**
variable	**OR**	(95% CI)	**OR**	(95 % CI)	**OR**	(95% CI)	**OR**	(95% CI)	**2005-2010**
Occupation									0.483
Manager	**1.00**		**1.0**		**1.00**		**1.0**		
Farmer	**0.54**	(0.20, 1.45)	**0.59**	(0.21, 1.65)	**0.79**	(0.19, 3.29)	**0.79**	(0.18, 3.44)	
Self-employed	**0.43**	(0.20, 0.90)*	**0.43**	(0.20, 0.92)*	**0.68**	(0.31, 1.50)	**0.78**	(0.35, 1.75)	
Professional	**0.94**	(0.57, 1.54)	**0.98**	(0.59, 1.61)	**1.43**	(0.89, 2.45)	**1.50**	(0.87, 2.61)	
Employee	**0.62**	(0.40, 0.96)*	**0.66**	(0.42, 1.03)	**0.85**	(0.52, 1.37)	**0.89**	(0.54, 1.46)	
Manual worker	**0.52**	(0.29, 0.92)*	**0.51**	(0.28, 0.92)*	**0.58**	(0.33, 1.01)	**0.67**	(0.37, 1.21)	
Other	**0.75**	(0.38, 1.49)	**0.81**	(0.40, 1.62)	**0.33**	(0.18, 0.60)*	**0.51**	(0.26, 1.00)	
Income									0.364
>€1500	**1.00**		**1.00**		**1.00**		**1.0**		
€1000-1500	**0.46**	(0.32, 0.65)**	**0.54**	(0.37, 0.79)**	**0.66**	(0.43, 1.01)	**0.79**	(0.50, 1.25)	
<€1000	**0.32**	(0.21, 0.49)**	**0.44**	(0.28, 0.70)**	**0.33**	(0.22, 0.49)**	**0.47**	(0.29, 0.76)**	
RII	**0.16**	(0.09, 0.28)**	**0.25**	(0.13, 0.48)**	**0.20**	(0.11, 0.37)**	**0.31**	(0.15, 0.64)*	0.295
Education level									0.828
Superior BAC	**1.00**		**1.00**		**1.00**		**1.0**		
BAC	**0.95**	(0.63, 1.45)	**1.01**	(0.66, 1.55)	**0.97**	(0.59, 1.58)	**0.99**	(0.60, 1.63)	
Inferior BAC	**0.57**	(0.41, 0.77)**	**0.57**	(0.41, 0.80)**	**0.51**	(0.35, 0.73)**	**0.63**	(0.43, 0.94)*	
RII	**0.36**	(0.21, 0.61)**	**0.36**	(0.21, 0.64)**	**0.28**	(0.16, 0.51)**	**0.40**	(0.22, 0.74)*	0.881
Employment									0.392
Employed	**1.00**		**1.00**		**1.00**		**1.0**		
Unemployed	**0.38**	(0.23, 0.61)**	**0.46**	(0.28, 0.75)*	**0.42**	(0.26, 0.67)**	**0.49**	(0.30, 0.81)*	
Inactive	**0.52**	(0.38, 0.71)**	**0.50**	(0.36, 0.71)**	**0.38**	(0.28, 0.52)**	**0.50**	(0.35, 0.73)**	
Complementary health insurance									0.014
Yes	**1.00**		**1.00**		**1.00**		**1.0**		
No	**0.25**	(0.15, 0.40)**	**0.29**	(0.17, 0.49)**	**0.54**	(0.34, 0.88)*	**0.64**	(0.38, 1.08)	
Basic health insurance									0.677
Yes	**0.46**	(0.29, 0.74)*	**0.57**	(0.35, 0.92)*	**0.42**	(0.28, 0.65)**	**0.52**	(0.32, 0.85)*	
No	**1.00**		**1.00**		**1.00**		**1.00**		

*p<0.05, **p<0.001.

[†]Adjusted on the covariates: age, region, alcohol consumption, smoking status, close relative with cancer & living in couple

[‡]Calculated by the interaction term for the change in Adjusted OR and Adjusted RII between 2005 and 2010

Table 5. Association between socio-economic variables and the probability of FOBT participation in 2005 and 2010: unadjusted[†] and adjusted Odds Ratios

	FOBT 2005 (n=1222)				FOBT 2010 (n=1425)				
Socio-economic variable	**Unadjusted OR**	(95% CI)	**Adjusted OR**	(95% CI)	**Unadjusted OR**	(95% CI)	**Adjusted OR**	95% CI	***p*-trend[‡] 2005-2010**
Occupation									0.372
Manager	**1.00**		**1.0**		**1.00**		**1.0**		
Farmer	**0.57**	(0.29, 1.10)	**0.61**	(0.31, 1.21)	**0.97**	(0.46, 2.05)	**0.72**	(0.32, 1.61)	
Self-employed	**0.78**	(0.46, 1.31)	**0.70**	(0.41, 1.20)	**0.82**	(0.51, 1.31)	**0.80**	(0.48, 1.32)	
Professional	**0.83**	(0.57, 1.23)	**0.90**	(0.60, 1.34)	**0.85**	(0.60, 1.20)	**0.94**	(0.65, 1.37)	
Employee	**0.66**	(0.45, 0.96)*	**0.83**	(0.60, 1.24)	**0.78**	(0.54, 1.12)	**0.99**	(0.66, 1.50)	
Manual worker	**0.67**	(0.44, 1.03)	**0.69**	(0.44, 1.07)	**0.66**	(0.45, 0.96)*	**0.63**	(0.42, 0.96)*	
Other	**0.76**	(0.39, 1.46)	**0.85**	(0.42, 1.73)	**0.58**	(0.36, 0.95)*	**0.71**	(0.41, 1.23)	
Income									0.114
>€1500	**1.00**		**1.00**		**1.00**		**1.00**		
€1000-1500	**0.85**	(0.61, 1.18)	**0.93**	(0.66, 1.31)	**0.94**	(0.67, 1.31)	**1.00**	(0.68, 1.46)	
<€1000	**0.63**	(0.42, 0.94)*	**0.62**	(0.39, 0.97)*	**0.89**	(0.62, 1.29)	**0.99**	(0.64, 1.52)	
RII	**0.54**	(0.31, 0.93)*	**0.70**	(0.38, 1.28)	**0.83**	(0.49, 1.41)	**0.99**	(0.52, 1.86)	0.137
Education level									0.441
Superior BAC	**1.00**		**1.00**		**1.00**		**1.00**		
BAC	**0.79**	(0.50, 1.24)	**0.85**	(0.53, 1.34)	**1.21**	(0.81, 1.83)	**1.25**	(0.80, 1.95)	
Inferior BAC	**0.77**	(0.58, 1.04)	**0.75**	(0.55, 1.02)	**0.99**	(0.74, 1.34)	**0.94**	(0.68, 1.30)	
RII	**0.67**	(0.41, 1.09)	**0.69**	(0.42, 1.14)	**0.90**	(0.56, 1.45)	**0.81**	(0.48, 1.35)	0.466
Employment									0.800
Employed	**1.00**		**1.00**		**1.00**		**1.00**		
Unemployed	**0.86**	(0.40, 1.88)	**1.09**	(0.49, 2.40)	**0.68**	(0.37, 1.27)	**0.86**	(0.45, 1.66)	
Inactive	**1.45**	(1.12, 1.88)*	**1.18**	(0.83, 1.67)	**1.58**	(1.25, 1.99)**	**1.14**	(0.82, 1.58)	
Complementary health insurance									0.485
Yes	**1.00**		**1.00**		**1.00**		**1.00**		
No	**0.50**	(0.25, 0.97)*	**0.53**	(0.26, 1.05)	**0.65**	(0.40, 1.05)	**0.81**	(0.47, 1.38)	
Basic health insurance									0.388
Yes	**0.70**	(0.43, 1.16)	**0.75**	(0.47, 1.22)	**1.03**	(0.69, 1.54)	**1.06**	(0.68, 1.65)	
No	**1.00**		**1.00**		**1.00**		**1.00**		

*p<0.05, **p<0.001.

[†]Adjusted on the covariates: age, region, alcohol consumption, smoking status, close relative with cancer & living in couple

[‡]Calculated by the interaction term for the change in Adjusted OR and Adjusted RII between 2005 and 2010

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found**: Included, please see page 1 and 2.**
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported **Included, please see 5 and 6**
Objectives	3	State specific objectives, including any prespecified hypotheses**. Included please see page 6, last sentence.**
Methods		
Study design	4	Present key elements of study design early in the paper. **Included, please see page 7, study population section, first paragraph.**
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection. **Included, please see page 7, study population section, second paragraph.**
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants**. Included, please see page 7, study population section, first paragraph.**
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable**. Included, please see page 8, Measures section.**
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group. **Included, please see page 8, Measures section.**
Bias	9	Describe any efforts to address potential sources of bias. **Included, please see page 7, second sentence, study population section, and page 8, last paragraph, Measures section.**
Study size	10	Explain how the study size was arrived at**. Included, please page 7, second paragraph, study population section.**
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why**. Included, please page 8, Measures sections.**
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding **Included, please page Statistical Analysis section pages 9-10**
		(*b*) Describe any methods used to examine subgroups and interactions **Included,**

	please statistical analysis section, second and third paragraphs.
	(*c*) Explain how missing data were addressed. **Included, please see page 7, study population section, second paragraph.**
	(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy**. Included, please see page 8, Measures section, last paragraph.**
	(*e*) Describe any sensitivity analyses. **N/A.**

Continued on next page

Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed **YES**
		(b) Give reasons for non-participation at each stage **YES**
		(c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders **YES**
		(b) Indicate number of participants with missing data for each variable of interest **YES**
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures **YES**
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included **YES**
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period **YES**
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results	18	Summarise key results with reference to study objectives **YES**
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias **YES**
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence **YES**
Generalisability	21	Discuss the generalisability (external validity) of the study results **YES**
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based **YES**

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Temporal trend in socio-economic inequalities in the uptake of cancer screening programs in France between 2005 and 2010: Results from the Cancer Barometer surveys

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ABSTRACT

Objectives: Cancer screening is a form of secondary prevention for a disease which is now the leading cause of death in France. Various socio-economic-indicators have been identified as potential factors for disparities in breast, cervical and colorectal cancer screening uptake. We aimed to identify the socioeconomic-inequalities which persisted in screening uptake for these cancers, and to quantify these disparities over a 5-year period.

Setting: The Cancer-Barometer was a population-based-survey carried out in 2005 and 2010 in France.

Participants: A randomly selected sample of participants aged 15 to 85 years (n=3820 in 2005 and n=3727 in 2010) were interviewed on their participation in breast, cervical and colorectal cancer screening programs and their socioeconomic profile.

Primary and secondary outcome measures: For each type of screening-program, we calculated participation rates, odds ratios (OR) and relative inequality indices (RII) for participation, derived from logistic regression of the following socioeconomic variables: income, education, occupation, employment and health insurance. Changes in participation between 2005 and 2010 were then analyzed.

Results: Participation rates for breast and colorectal screening increased significantly along the majority of socioeconomic categories, whereas for cervical cancer screening there were no significant changes between 2005 and 2010. RIIs for income remained significant for cervical smear in 2005 (RII=0.25, 95% CI 0.13-0.48) and in 2010 (RII=0.31, 95% CI 0.15-0.64). RIIs for education in mammography (RII=0.43, 95% CI 0.19-0.98) and cervical smear (RII=0.36, 95% CI 0.21-0.64) were significant in 2005 and remained significant for cervical smear (RII=0.40, 95% CI 0.22-0.74) in 2010.

Conclusions: There was a persistence of socioeconomic inequalities in uptake of opportunistic cervical cancer screening. Conversely, organized screening-programs for breast and colorectal cancer saw a reduction in relative socioeconomic inequalities, even though the results were not statistically significance. The findings suggest that organized-cancer-screening programs may have the potential to reduce socio-economic disparities in participation.

Key words: cancer screening, breast cancer, cervical cancer, social inequalities, cancer epidemiology

Strengths and limitations of this study

- First study to examine temporal changes in inequalities for cancer screening uptake in France using relative inequality index.
- Benefits from datasets of two identical questionnaires on cancer screening uptake, taken 5 years apart, using two comparable population samples, hence minimizing information bias.
- Evolution in the format of colorectal screening program in terms of technique and age limits may have led to measured differences in uptake between 2005 and 2010.
- Residents of nursing homes and other medical institutions without a personal telephone line were excluded from the survey, limiting the generalizability of the findings.
- Relatively small number for certain socio-economic strata, reducing therefore the precision of some estimates.

INTRODUCTION

Screening for cancer is an important form of secondary prevention for a disease which is now leading cause of death in France and worldwide [1]. The 2008 European report on cancer recommends that health systems focus their resources on cancer prevention and early detection rather than treatment alone, as the global disease burden of cancer threatens to become unsustainable in terms of financial costs, pressure on services, follow-up of patients and delivery of care [2].

To date, many European countries have rolled out screening programs for breast, colorectal and cervical cancer via mammography, faecal occult blood test (FOBT) and cervical smear respectively [3, 4]. However, for these screening programs to have a significant effect on reducing cancer mortality, they require a minimum level of participation among the eligible population; for instance 70% for mammography, and 50% for FOBT [5].

We reviewed several publications from France, UK, USA, Italy, Denmark, Korea and Argentina, which identified variables shown to have a significant effect on cancer screening uptake [6-19]. For breast cancer screening, various different social and economic variables were found to have a positive effect on uptake, including employment, higher occupation class, higher education level, income, private health insurance, car/home ownership. However, no single variable was consistently observed across studies except for participation in other screening programs [7, 18]. For cervical cancer screening, the variables identified as having a significant positive effect on uptake were more numerous, and notably consistent for income [7, 11, 17], higher education level [10-12, 17, 18], employment [6, 12, 18, 19] and private health insurance [6, 7, 18]. For colorectal screening, income was consistently shown to have a significant positive effect on uptake of screening across the studies [14, 16, 18]. However, it remains unclear whether the effect of these socio-economic variables on participation rates in screening programs persists over time.

Only one study drawn from the 2006, 2008 and 2010 French Healthcare and Health Insurance surveys has examined the temporal evolution in breast, cervical and colorectal cancer screening uptake in France to date [6]. This study conducted among 10 000 participants found that those classified as unskilled workers were more likely to have not undergone cervical cancer screening (OR = 1.64 [1.38-1.95]) when compared to those with an intermediate profession. The results also showed that women without (OR = 2.05 [1.68-2.51]) or receiving free complementary health insurance (OR = 1.79 [1.36-2.37]) were more likely to have not undergone breast cancer screening when compared to those with a private complementary health insurance. In this study, the authors found that inequalities for participation in breast and colorectal cancer screening persisted over the study period from 2006 to 2010 [6]. Thus, we believe that there is a need to re-examine how these trends may have evolved with respect to expansion in the coverage and awareness of organized cancer screening programs. The third French National Cancer Plan for the 2014-2019 period has identified early detection of cancers as a primary priority [20]. Within this goal is the reduction of inequalities associated with cancer diagnosis, with the hope that it subsequently reduces mortality rates. Any widening or reduction in socio-economic inequalities in the uptake of screening programs that are identified may then be used to direct future policy of the French national cancer control plan, which specifically seeks to address this issue [20]. We aim therefore in the present study to identify the socio-economic inequalities which persist for uptake of breast, cervical and colorectal cancer screening, and to quantify these disparities over a 5 year period in France.

MATERIALS AND METHODS

Study population

We used data, obtained by formal permission, from the Cancer Barometer surveys, two telephone surveys on cancer-related knowledge, attitudes and practices conducted by the French National Institute for Prevention and Health (now part of Santé Publique France). Both surveys were carried out on a representative random sample of the general French population aged over 16 years old for the 2005 survey and aged 15–85 years old for the 2010 survey. A two-stage random sampling design was used. Residents of nursing homes or other medical institutions who did not possess a personal telephone line were not included in the samples. Private households with telephones were included in the sample. The first sampling step was household selection (by phone number). Within each selected household, one French speaking person aged 15–85 was randomly selected using the "next birthday" method. The study protocol included a formal request to participate, explaining the objectives of the study that was delivered by mail before the first telephone call. Informed consent was obtained at the start of the telephone interview, in accordance with the guidelines of the French Data Protection Authority (CNIL). The interviews were conducted using a computer-assisted telephone interview (CATI) system.

In order to obtain adequate statistical power for measuring associations between variables and changes in participation rates along smaller levels, a sample size of between 3500 and 4000 was deemed appropriate. The 2005 Cancer Barometer sample was comprised of 4046 participants aged over 16 years interviewed between April and June 2005 [18]. There were 226 individuals with missing observations in the 2005 Cancer Barometer sample, notably for all 3 of the dependent variables, and 7 out of 10 of the covariates and independent variables. These individuals terminated the survey prematurely, and were thus removed from the analysis as their data was non-contributive, leaving 3820 participants in the sample population. Females (51.5%) responded more

often than males (48.5%) and mean age of interviewees was 46.7 years. The 2010 Cancer Barometer sample was comprised of 3727 participants aged 15 to 85 interviewed during the first semester of 2010 [19]. The mean age was 44.6 years and the majority of participants were also female (52.0%vs. 48.0%). The response rates for the 2005 and 2010 Cancer Barometers were 51.2% and 47.0%, respectively.

Measures

Socio-economic indicators (independent variables) were as follows: education level (inferior, equal to or superior to baccalauréat (high-school diploma), employment status (employed, unemployed, and inactive), occupational class (farmer, trader, manager, professional, employee, manual worker, other), monthly income (below €1000, €1000-1500, above €1500) and health insurance (private complementary vs. basic insurance coverage). The outcome variables were participation in breast, cervical and colorectal cancer screening programs (dependent variables). For breast cancer screening, participants aged over 40 years were asked if they had undergone mammography within the previous 2 years. For cervical cancer screening, participants aged over 20 years were asked if they had undergone a cervical smear within the previous 3 years. For colorectal cancer screening, participants aged 50-74 years were asked if they had undergone a faecal occult blood test (FOBT) within their lifetime. Covariates included gender, age, smoking status, alcohol consumption, region, living in a couple and having a close relative with cancer. For the calculation of screening participation rates, we added filters to select the target population eligible for each of the 3 different screening programs. Breast screening by mammography (n=1546): female gender and 49<age<75. Cervical screening by cervical smear (n=3085): female gender and 24<age<66. Colorectal screening by FOBT (n=2647): both genders where 49<age<75.

The weighting was based on the data of the 1999 and 2008 Employment Survey of the French population [21], taking into account age, gender, region, education level and number of persons per

household [18]. This allowed us to effectively calculate age-adjusted standardized rates for screening participation, in addition to later adjusting the regression models on the covariates mentioned.

Statistical analysis

We created a pooled dataset of the two surveys conducted in 2005 and 2010. We calculated age-adjusted screening rates (AAR) for each stratum using the weighting provided by the INPES. The temporal evolution in the participation rate along each stratum between 2005 and 2010 was examined by adding an interaction term with the year of the survey. The disparity within each socio-economic variable was calculated as the absolute difference between the AAR for the highest and lowest group within an ordinal or binary variable for the given year.

Odds ratios (OR) derived from multiple logistic regression of screening participation on each socio-economic variable separately were used as a measure of participation likelihood for each stratum of the 6 socio-economic variables. The model was adjusted on the covariates: age, gender (colorectal screening only), region, alcohol, smoking, living in couple and close relative with cancer. For categorical variables, the higher socio-economic position was used as the reference group. The trend of disparities within each socioeconomic variable for each survey was then estimated and compared using a two way interaction term composed of socioeconomic variable of interest and survey year dummy variable (2010 vs. 2006), in order to be consistent with the methodology of previous studies on the topic [22, 23].

For ordinal variables of income and education level, we calculated the Relative Inequality Index (RII) as a measure of health inequality as described by Mackenbach and Kunst [24]. Previous studies on health inequalities, including breast cancer screening uptake [4, 9], employed a similar methodology for examining temporal evolutions along ordered socio-economic strata [23, 25]. The trend of RII for each survey was estimated and compared using a two way interaction term

composed of socioeconomic variable of interest and survey year dummy variable (2010 vs. 2006). The RII is a regression-based measure that summarizes the association between two variables. It is computed by ranking income and education values on a scale from the lowest, which is 0, to the highest, which is 1. Each income or education level value covers a range on this scale that is proportional to the number of participants who held that value and is given a new value on the scale corresponding to the cumulative midpoint of its range. The RII resembles relative risk in that it compares the probability of cancer screening uptake at the extremes of income and educational levels, but is estimated using the data on all income and education values and is weighted to account for the distribution of these values. Here the RII was fitted using logistic regression models. An RII of 0.5 for example implies that participants in the most deprived group (those with lower incomes and educations levels) had a 50% lower probability of cancer screening uptake when compared to those in the least deprived group (those with higher incomes and education levels). All statistical analysis was performed using SAS version 9.2.

RESULTS

Table 1 presents the demographic and socio-economic characteristics of the study populations. The overall participation rates among the eligible populations for breast, cervical and colorectal cancer screenings are shown in Table 2. Chi-squared tests for the change in participation rates along each socio-economic stratum between 2005 and 2010 are also included. For mammography, participation rates increased significantly ($p<0.05$) along all socio-economic strata, with the exception of farmers, managers, manual workers, unemployed, those with basic health insurance and education level superior to baccalauréat. For FOBT, participation rates increased significantly along all socio-economic strata between 2005 and 2010, with the exception of those unemployed or occupation classified as other. For cervical smear there were no significant changes

in participation rates along any of the socio-economic strata, except for those without complementary health insurance, which increased significantly from 52.51% to 71.0% (p=0.017).

Table 3 shows the results of the logistic regression models for mammography participation on each socio-economic variable separately, adjusted for covariates. In 2005, farmers, self-employed, employees and manual workers showed significantly reduced participation compared to managers/executives, whereas in 2010 only the association in manual workers remained significant. In 2005, those with an education level inferior to baccalauréat (OR=0.57, 0.35-0.95) showed significantly reduced participation compared to those superior to baccalauréat, which became non-significant in 2010 (OR=1.04, 0.53-2.05).

Table 4 shows the results of the regression model for cervical smear participation for each socio-economic variable. In 2005, significantly reduced participation was observed for self-employed and manual workers, which became non-significant for both in 2010. In 2005, there was significantly reduced participation for those earning <€1000 and €1000-€1500, which remained significant in 2010 for those earning <€1000 (OR=0.47, 95% CI 0.29-0.76). An education level inferior to baccalauréat showed significantly lower participation in both 2005 and in 2010. In 2005, being unemployed or inactive significantly reduced participation, and remained significant for both in 2010. The odds ratio for cervical smear participation changed significantly (p=0.014) for those without complementary health insurance from 0.29 (95% CI 0.17-0.49) in 2005 to 0.64 (95% CI 0.38-1.08) in 2010. Having only basic health insurance was significantly associated with reduced participation in both periods.

Table 5 shows the logistic regression results for FOBT participation on each socio-economic variable. For occupation, manual workers (OR=0.63, 95% CI 0.42-0.96) showed significantly reduced participation in 2010. Odds ratios for all other occupations showed reduced participation compared to managers, but at a non-significant level in 2005 and 2010. Those earning <€1000

showed reduced participation in 2005 (OR=0.62, 95% CI 0.32-0.97), which became non-significant in 2010. There were no significant temporal changes in any of the odds ratios for participation in breast or colorectal cancer screening between 2005 and 2010.

The regression of screening participation on income distribution produced RIIs which can be found in Tables 3-5. The results showed significant inequalities for cervical smear (RII=0.25, 95% CI 0.13-0.48) in 2005, but not for mammography (RII=0.47, 95% CI 0.19-1.29) or FOBT (RII= 0.70, 95% CI 0.38-1.28). In 2010 the income-based RII remained significant for cervical smear (RII=0.31, 0.15-0.64). For education, mammography (RII=0.43, 95% CI 0.19-0.98) and cervical smear (RII=0.36, 95% CI 0.21-0.64) showed significant inequalities in 2005, whereas the RII for FOBT was non-significant (RII=0.69, 95% CI 0.42-1.14). In 2010, the education-based RII for mammography became non-significant (RII=0.80, 95% CI 0.26-2.50), whereas the RII for cervical smear remained significant (RII=0.40, 95% CI 0.22-0.74). The p-trend for the temporal change in the RIIs (adjusted model) measured by interaction term between 2005 and 2010, was non-significant for all 3 screening programs for income and education level.

DISCUSSION

Our objective was to identify the socio-economic inequalities which persisted for uptake of breast, cervical and colorectal cancer screening, and to quantify these disparities between the 2005 and 2010. In absolute terms, a significant increase in participation rates was observed for most socio-economic strata for mammography and for FOBT between 2005 and 2010. Cervical cancer screening however saw no significant change in participation rates between 2005 and 2010 (except for those without complementary health insurance). A similar trend was observed when relative inequalities were considered. It should be noted that some of these inequalities were persistent between 2005 and 2010, even though formal statistical tests for trend were generally not significant.

Findings in the context of the literature

We found only one study that has examined the temporal evolution in breast, cervical and colorectal cancer screening uptake in France to date [6]. However, an important difference between our study and that study conducted by Sicsic and Franc relies on their objectives and consequently on the methods used to reach them. The study by Sicsic and Franc aimed to analyze the obstacles to and levers for breast, cervical, and colorectal cancer screening uptake and their trends over time, whereas the aim of our study was to identify the socio-economic inequalities which persist for uptake of breast, cervical and colorectal cancer screening, and to quantify these disparities over a 5 year period. Thus, Sicsic and Franc pooled their three samples but did not conduct direct comparisons of associations between indicators of socioeconomic position and uptake of cancer screenings between periods.

The sole point of comparison between the two studies concerns the overall participation in screening programs. Sicsic and Franc found that the screening rate for breast cancer decreased between 2006 and 2010, from 77.6% in 2006 to 74.0% in 2010", but the difference was not statistically significant. Although, we found an increase in participation rates for breast cancer screening, it was not statistically significant at the level of 5%. They also found that colorectal cancer screening uptake increased significantly between 2006 and 2010, from 18.2% in 2006 to 38.9% in 2010. This is consistent with our result showing that colorectal cancer screening uptake significantly increased from 34.0% in 2005 to 51% in 2010. Finally, they found that the screening rate for cervical cancer significantly decreased from 75.3% in 2006 to 71.9% in 2010. For cervical cancer, we found that the rate was stable between 2006 (79.7) and 2010 (81.4). In definitive, differences in sampling, sample sizes, number of data collection phases, and in desirability bias may explain these differences in participation rates. It should be also noted that the study by Sicsic and Franc was based on three surveys carried out in 2006, 2008 and 2010, with therefore a two-year

interval, whereas the Cancer Barometer survey was conducted at two points in time in 2005 and 2010. Our study confirmed significantly reduced participation for manual workers in breast and colorectal screening and for those with only basic health insurance in breast and cervical screening in 2010. This is consistent with the study by Sicsic and Franc which showed reduced participation in all 3 screening programs for manual workers and those with only basic health insurance. Breast and colorectal cancer screening programs saw the absolute differences in participation rates reduced over time for all socio-economic variables in our study, with the exception of employment and basic health insurance. An American study by Kim et al. showed the disparity in mammography participation based on income remained unchanged, while the disparity based on education decreased from 2000 to 2005 [9]. Cervical cancer screening however saw a persisting disparity in participation rates for the majority of socio-economic variables in our study, consistent with the results of De Maio et al. and Sicsic and Franc [6, 17].

The relative inequalities for income and education decreased for breast and colorectal cancer screening in our study, albeit non-significantly. This is somewhat consistent with DeMaio et al., which showed a reduction in the RII for breast cancer screening from 2005 to 2009 [17]. In the study by Kim et al., the income-based relative inequalities tended to decrease slightly, while those for education remained constant over time [9]. The relative inequalities for cervical cancer screening persisted for both income and education from 2005 to 2010 in our study, both remaining statistically significant. This is partially consistent with the De Maio et al., where the social gradient decreased for income and increased for education between 2005 and 2010 [17].

Interpretation of results

Breast and colorectal screening programs are organized at a national level and differences in absolute participation rates and relative inequalities decreased over time for all socio-economic variables. For both breast and colorectal screening, the odds ratios for manual workers showed

reduced participation compared to managers/executives in 2010. Education and occupation are strongly correlated, with manual workers having a higher proportion of participants with an educational level inferior to baccalauréat (85%) than any other occupational category in 2010. Thus they may have been less aware of the health marketing campaigns for colorectal cancer screening and the recommendation for FOBT, due to the negative effect of lower education on health literacy [14, 26, 27].

Cervical cancer remains without a nationally organized screening program in France. It is the duty of doctors to organize and falls to the individual to pay for opportunistic screening via cervical smear test. The lack of a nationally organised screening program may impose significant financial, educational and cultural barriers to screening uptake among certain sections of the French population. The financial costs for a consultation and laboratory processing of the screening test may deter those with only basic health insurance, as public reimbursement covers only 70% of the cost [28]. This may account for the persistence of the observed differences in participation rates and large RIIs. Improving the awareness, affordability and access to cervical cancer screening should be prioritised in order to increase participation rates and reduce socio-economic disparities.

Limitations and strengths of the study

Our study used two almost identical datasets to construct a temporal analysis of participation in screening programs in France between 2005 and 2010. The use of relative inequality indices to measure the evolution of socio-economic inequalities in our study is the first to employ this methodology among a French population for cancer screening. The comparability of the study populations minimized selection bias and the conservation of the questionnaire format minimized information bias.

The study still has several limitations however. It shares the usual shortcomings of phone surveys. There is a potential selection bias, as residents of nursing homes or other medical

institutions who did not possess a personal telephone line were not included in the samples. The study includes only those who are French speakers, excluding individuals unable to answer fluently in French. There was no available data on ethnicity or nationality of participants in the study, which may have been an important source of confounding or effect modification. The exclusion of the above subpopulations, which are likely to be more socio-economically disadvantaged, may have overestimated the screening participation rates in our study.

Our study used two separate sample populations, whose distributions in Table 2 differed significantly for all of the socio-economic indicators and several covariates. The difference in sample distributions may have accounted for the observed differences in screening participation rates. Thus, we cannot rule out that reductions observed in inequalities over time are not simply due to changes in socioeconomic distributions rather than an actual reduction in social inequalities in screening participation.

Changes in screening policies concerning age limits, screening techniques and regional access left the 2005 and 2010 Cancer Barometers not directly comparable for certain programs. The question of screening participation for colorectal cancer was therefore limited to lifetime use of FOBT. Organized cervical screening was available in 13 regions in 2009, a source of regional variation not present in 2005. Some screening techniques are more memorable to patients, due to the invasiveness of the screening technique or the duration of the screening intervals, which may have led to recall bias.

The respective analytical sample sizes in 2005 and 2010 for breast (n=742, n=804), cervical (n=1571, n=1514) and colorectal (n=1222, n=1425) cancer screening may have been too small to capture disparities along socio-economic strata, leading to false observations and conclusions. Missing observations for each variable accounted for less than 5% of the total population, except for the variable income (16.3% missing in 2005 and 9.3% in 2010). This might have limited the

precision of certain estimates, producing participation rates with large standard errors and odds ratios with large confidence intervals. We undertook multiple comparisons in our study. Thus, we cannot exclude that some of the results we have observed are due to chance.

Conclusion

The findings suggest that organized cancer screening programs may have the potential to reduce socio-economic disparities in participation.

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All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf and declare: no support from any organisation for the submitted work; no financial relationships with any organisations that might have an interest in the submitted work in the previous three years; no other relationships or activities that could appear to have influenced the submitted work.

Contributors

HN conceived the study, advised on methodology, reviewed the results of statistical analyses and supervised the final edit of the manuscript. DK reviewed the background literature, run statistical analyses and drafted the manuscript. CE, CL, PA provided advice on methodology and statistical analyses. CL & PA directed the data collection. All authors contributed to the final draft of this manuscript.

Data sharing statement

All data presented in this manuscript came from 2 original datasets of the 2005 and 2010 Cancer Barometer surveys. The original files can be requested by contacting Santé Publique France (formerly INVS and INPES) via Pierre Arvidson (pierre.arwidson@santepubliquefrance.fr) or Christophe Léon (christophe.leon@santepubliquefrance.fr).

Table 1. Standardized† distribution of study populations for 2005 and 2010 Cancer Barometer surveys, p-value for Chi-squared test

Variables	Barometer 2005 (n=3820)		Barometer 2010 (n=3727)		p-value
	n	%	n	%	
Gender					0.660
Male	1854	48,5	1790	48,0	
Female	1966	51,5	1937	52,0	
Region					0.976
Ile-de-France	701	18,4	696	18,7	
West Paris basin	380	10,0	348	9,3	
East Paris basin	305	8,0	290	7,8	
North	257	6,7	238	6,4	
West	508	13,3	504	13,5	
East	334	8,8	321	8,6	
South West	414	10,9	412	11,1	
South East	455	12,0	447	12,0	
Mediterranée	457	12,0	471	12,6	
Occupation					<0.001
Farmer	117	3,1	81	2,2	
Self-employed/craftsman	220	5,8	270	7,2	
Manager/executive	589	15,4	595	16,0	
Professional	773	20,3	914	24,5	
Employee/office worker	970	25,4	829	22,3	
Manual worker	642	16,8	839	22,5	
Oher	506	13,3	199	5,3	
Education level					<0.001
Inferior BAC*	1946	52,0	2270	61,2	
BAC	651	17,4	635	17,1	
Superior BAC	1146	30,6	803	21,7	
Monthly Income					<0.001
<€1000	414	13,2	399	12,1	
€1000-1500	663	21,0	499	15,1	
>€1500	2075	65,8	2401	72,8	
Employment					<0.001
Employed	2146	56,2	1851	49,7	
Unemployed	177	4,6	260	7,0	
Inactive	1497	39,2	1615	43,3	
Alcohol consumption					<0.001
Yes	3430	89,8	3195	85,7	
No	389	10,2	532	14,3	
Smoking status					<0.001
Yes	964	25,2	1195	32,1	
No	2856	74,8	2532	67,9	
Close Relative with cancer					0.950
Yes	2366	62,1	2198	62,1	
No	1446	37,9	1339	37,9	
Living in couple					0.071
Yes	2465	64,6	2333	62,6	
No	1351	35,4	1394	37,4	
Complementary Health Insurance					<0.001
Yes	3518	92,6	3210	89,6	
No	282	7,4	375	10,5	
Basic Health Insurance					0.003
Yes	361	10,2	441	12,4	
No	3182	89,8	3109	87,6	

* BAC = Baccalauréat (high-school diploma)

†Weighted by age, gender, region and educational level according to standard population of the 1999 and 2008 Employment Surveys (INSEE)

Table 2. Standardized† participation rates for eligible participants in 3 screening programs, Chi-squared test for 2005-2010, *p*-trend

Socio-economic variable	Mammography			Cervical smear			FOBT		
	participation rate (%) ± SE			participation rate (%) ± SE			participation rate (%) ± SE		
	2005 (n=742)	2010 (n=804)	Chi2 *p*-value	2005 (n=1571)	2010 (n=1514)	Chi2 *p*-value	2005 (n=1222)	2010 (n=1425)	Chi2 *p*-value
Overall	72.1	88.3		79.7	81.4		34.0	51.6	
Occupation									
Farmer	62.49 ±8.24	87.64 ±8.81	0.148	75.61 ±7.28	80.39 ±11.63	0.739	26.97 ±6.69	56.50 ±10.82	0.006
Self-employed	63.70 ±9.46	85.96 ±5.37	0.027	71.02 ±7.00	77.92 ±6.89	0.438	33.47 ±5.61	52.30 ±5.75	0.009
Manager	85.50 ±4.04	91.45 ±2.50	0.262	85.15 ±2.51	83.88 ±3.05	0.740	39.33 ±3.89	57.33 ±3.31	0.0003
Professional	74.87 ±3.74	87.82 ±2.95	0.004	84.31 ±1.95	88.17 ±1.68	0.153	35.04 ±3.21	53.32 ±2.79	<0,0001
Employee	68.76 ±3.00	90.58 ±1.98	<0.0001	78.05 ±1.81	81.52 ±2.06	0.170	29.92 ±2.63	51.07 ±3.54	<0,0001
Manual worker	64.52 ±6.01	76.02 ±5.29	0.161	74.70 ±3.96	75.00 ±4.22	0.956	30.29 ±3.74	46.95 ±4,23	0.001
Other	69.37 ±6.19	83.70 ±5.28	0.097	81.14 ±4.21	62.94 ±6.53	0.010	32.87 ±6.20	43.84 ±6.92	0.204
Education level									
Inferior BAC	67.80 ±2.29	86.26 ±1.79	<0.0001	75.20 ±1.77	76.88 ±1.97	0.484	31.55 ±1.82	51.06 ±2.06	0
BAC	71.86 ±5.71	93.63 ±2.15	0.0003	83.59 ±2.47	86.42 ±2.03	0.385	32.07 ±4.46	56.06 ±3.58	<0,0001
Superior BAC	80.17 ±3.49	87.34 ±2.56	0.153	84.27 ±1.65	86.81 ±1.67	0.318	37.39 ±3.27	51.23 ±2.92	0.002
Difference	*12.37*	*1.08*		*9.07*	*9.93*		*5.84*	*0.17*	
Income									
<€1000	58.45 ±4.48	82.62 ±3.92	0.001	64.78 ±4.01	64.81 ±4.70	1	27.02 ±3.55	49.40 ±4.79	0.0001
€1000-1500	68.62 ±4.19	84.95 ±3.57	0.006	72.43 ±2.96	78.81 ±3.49	0.161	33.29 ±3.35	50.61 ±4.33	0.001
>€1500	76.21 ±2.65	89.57 ±1.59	<0.0001	85.21 ±1.25	84.96 ±1.36	0.885	37.07 ±2.23	52.29 ±1.96	<0,0001
difference	*17.76*	*6.95*		*20.43*	*20.15*		*10.05*	*2.89*	
Complementary health insurance									
Yes	72.09 ±1.84	88.08 ±1.38	<0.0001	81.77 ±1.08	81.83 ±1.29	0.964	33.63 ±1.53	52.31 ± 1.64	<0,0001
No	48.35 ±9.53	78.06 ±7.49	0.013	52.51 ±6.04	71.00 ±5.67	0.017	20.10 ±5.58	41.51 ±7.71	0.011
difference	*23.76*	*10.02*		*29.26*	*10.83*		*13.53*	*10.80*	
Basic health insurance									
Yes	66.12 ±7.38	69.98 ±8.60	0.694	67.20 ±4.70	67.22 ±5.47	1	26.23 ±4.56	52.75 ±6.93	0.0001
No	70.99 ±1.93	88.72 ±1.28	<0.0001	81.52 ±1.12	82.87 ±1.24	0.399	33.83 ±1.60	52.06 ±1.64	<0,0001
difference	*4.87*	*18.74*		*14.32*	*15.65*		*7.60*	*0.69*	
Employment									
Employed	76.23 ±3.07	89.0 ±2.21	0.001	83.75 ±1.21	86.56 ±1.34	0.097	28.37 ±2.42	45.11 ±2.56	<0,0001
Unemployed	66.26 ±9.44	84.1 ±8.73	0.176	66.00 ±5.25	72.88 ±5.23	0.304	25.48 ±6.60	35.91 ± 9.21	0.308
Inactive	68.58 ±2.32	86.79 ±1.75	<0.0001	72.72 ±2.51	71.15 ±2.73	0.665	36.51 ±1.93	56.48 ±2.03	<0,0001

†Weighted by age, gender, region and educational level according to standard population of the 1999 and 2008 Employment Surveys (INSEE)

Table 3. Association between socio-economic variables and the probability of participation in mammography in 2005 and 2010: unadjusted[†] and adjusted odds ratios

	Mammography 2005 (n=742)				Mammography 2010 (n=804)				
Socio-economic	**Unadjusted**		**Adjusted**		**Unadjusted**		**Adjusted**		***p*-trend[‡]**
variable	**OR**	(95% CI)	**OR**	(95% CI)	**OR**	(95% CI)	**OR**	(95 % CI)	**2005-2010**
Occupation									0.521
Manager	**1.00**		**1.0**		**1.00**		**1.0**		
Farmer	**0.28**	(0.10, 0.77)*	**0.33**	(0.12, 0.92)*	**0.66**	(0.08, 5.45)	**0.64**	(0.07, 5.54)	
Self-employed	**0.30**	(0.11, 0.81)*	**0.33**	(0.12, 0.93)*	**0.57**	(0.18, 1.86)	**0.60**	(0.18, 2.00)	
Professional	**0.51**	(0.23, 1.10)	**0.53**	(0.24, 1.18)	**0.67**	(0.26, 1.72)	**0.66**	(0.25, 1.74)	
Employee	**0.37**	(0.18, 0.77)*	**0.39**	(0.19, 0.82)*	**0.90**	(0.36, 2.26)	**1.13**	(0.43, 2.95)	
Manual worker	**0.31**	(0.13, 0.74)*	**0.34**	(0.14, 0.84)*	**0.30**	(0.11, 0.78)*	**0.34**	(0.12, 0.94)*	
Other	**0.38**	(0.16, 0.95)*	**0.45**	(0.17, 1.14)	**0.48**	(0.16, 1.47)	**0.59**	(0.18, 1.95)	
Income									0.775
>€1500	**1.00**		**1.00**		**1.00**		**1.00**		
€1000-€1500	**0.68**	(0.42, 1.11)	**0.83**	(0.50, 1.39)	**0.66**	(0.34, 1.27)	**1.04**	(0.49, 2.20)	
<€1000	**0.44**	(0.26, 0.73)*	**0.57**	(0.32, 1.03)	**0.55**	(0.29, 1.06)	**0.80**	(0.38, 1.68)	
RII	**0.29**	(0.14, 0.64)*	**0.47**	(0.19, 1.29)	**0.37**	(0.13, 1.00)	**0.78**	(0.23, 2.64)	0.781
Education level									0.403
Superior BAC	**1.00**		**1.00**		**1.00**		**1.00**		
BAC	**0.63**	(0.32, 1.26)	**0.61**	(0.30, 1.23)	**2.13**	(0.73, 6.18)	**2.09**	(0.70, 6.22)	
Inferior BAC	**0.52**	(0.32, 0.86)*	**0.57**	(0.35, 0.95)*	**0.91**	(0.48, 1.73)	**1.04**	(0.53, 2.05)	
RII	**0.36**	(0.16, 0.79)*	**0.43**	(0.19, 0.98)*	**0.62**	(0.21, 1.81)	**0.80**	(0.26, 2.50)	0.450
Employment									0.786
Employed	**1.00**		**1.00**		**1.00**		**1.00**		
Unemployed	**0.61**	(0.23, 1.62)	**0.60**	(0.23, 1.61)	**0.65**	(0.19, 2.20)	**0.74**	(0.21, 2.68)	
Inactive	**0.68**	(0.46, 1.01)	**0.93**	(0.57, 1.54)	**0.81**	(0.49, 1.36)	**1.30**	(0.65, 2.60)	
Complementary health insurance									0.859
Yes	**1.00**		**1.00**		**1.00**		**1.00**		
No	**0.36**	(0.16, 0.81)*	**0.41**	(0.18, 0.95)*	**0.48**	(0.22, 1.06)	**0.60**	(0.26, 1.42)	
Basic health insurance									0.121
Yes	**0.80**	(0.41, 1.54)*	**0.83**	(0.43, 1.61)	**0.30**	(0.15, 0.58)*	**0.41**	(0.20, 0.85)*	
No	**1.00**		**1.00**		**1.00**		**1.00**		

*p<0.05, **p<0.001.

[†]Adjusted on the covariates: age, region, alcohol consumption, smoking status, close relative with cancer & living in couple

[‡] Calculated using a two way interaction term composed of socioeconomic variable of interest and survey year dummy variable (2010 vs. 2006).

Table 4. Association between socio-economic variables and the probability of cervical smear participation in 2005 and 2010: unadjusted[†] and adjusted odds ratios

	Cervical smear 2005 (n=1571)				Cervical smear 2010 (n=1514)				
Socio-economic variable	**Unadjusted OR**	(95% CI)	**Adjusted OR**	(95 % CI)	**Unadjusted OR**	(95% CI)	**Adjusted OR**	(95% CI)	***p*-trend[‡] 2005-2010**
Occupation									0.483
Manager	**1.00**		**1.0**		**1.00**		**1.0**		
Farmer	**0.54**	(0.20, 1.45)	**0.59**	(0.21, 1.65)	**0.79**	(0.19, 3.29)	**0.79**	(0.18, 3.44)	
Self-employed	**0.43**	(0.20, 0.90)*	**0.43**	(0.20, 0.92)*	**0.68**	(0.31, 1.50)	**0.78**	(0.35, 1.75)	
Professional	**0.94**	(0.57, 1.54)	**0.98**	(0.59, 1.61)	**1.43**	(0.89, 2.45)	**1.50**	(0.87, 2.61)	
Employee	**0.62**	(0.40, 0.96)*	**0.66**	(0.42, 1.03)	**0.85**	(0.52, 1.37)	**0.89**	(0.54, 1.46)	
Manual worker	**0.52**	(0.29, 0.92)*	**0.51**	(0.28, 0.92)*	**0.58**	(0.33, 1.01)	**0.67**	(0.37, 1.21)	
Other	**0.75**	(0.38, 1.49)	**0.81**	(0.40, 1.62)	**0.33**	(0.18, 0.60)*	**0.51**	(0.26, 1.00)	
Income									0.364
>€1500	**1.00**		**1.00**		**1.00**		**1.0**		
€1000-1500	**0.46**	(0.32, 0.65)**	**0.54**	(0.37, 0.79)**	**0.66**	(0.43, 1.01)	**0.79**	(0.50, 1.25)	
<€1000	**0.32**	(0.21, 0.49)**	**0.44**	(0.28, 0.70)**	**0.33**	(0.22, 0.49)**	**0.47**	(0.29, 0.76)**	
RII	**0.16**	(0.09, 0.28)**	**0.25**	(0.13, 0.48)**	**0.20**	(0.11, 0.37)**	**0.31**	(0.15, 0.64)*	0.295
Education level									0.828
Superior BAC	**1.00**		**1.00**		**1.00**		**1.0**		
BAC	**0.95**	(0.63, 1.45)	**1.01**	(0.66, 1.55)	**0.97**	(0.59, 1.58)	**0.99**	(0.60, 1.63)	
Inferior BAC	**0.57**	(0.41, 0.77)**	**0.57**	(0.41, 0.80)**	**0.51**	(0.35, 0.73)**	**0.63**	(0.43, 0.94)*	
RII	**0.36**	(0.21, 0.61)**	**0.36**	(0.21, 0.64)**	**0.28**	(0.16, 0.51)**	**0.40**	(0.22, 0.74)*	0.881
Employment									0.392
Employed	**1.00**		**1.00**		**1.00**		**1.0**		
Unemployed	**0.38**	(0.23, 0.61)**	**0.46**	(0.28, 0.75)*	**0.42**	(0.26, 0.67)**	**0.49**	(0.30, 0.81)*	
Inactive	**0.52**	(0.38, 0.71)**	**0.50**	(0.36, 0.71)**	**0.38**	(0.28, 0.52)**	**0.50**	(0.35, 0.73)**	
Complementary health insurance									0.014
Yes	**1.00**		**1.00**		**1.00**		**1.0**		
No	**0.25**	(0.15, 0.40)**	**0.29**	(0.17, 0.49)**	**0.54**	(0.34, 0.88)*	**0.64**	(0.38, 1.08)	
Basic health insurance									0.677
Yes	**0.46**	(0.29, 0.74)*	**0.57**	(0.35, 0.92)*	**0.42**	(0.28, 0.65)**	**0.52**	(0.32, 0.85)*	
No	**1.00**		**1.00**		**1.00**		**1.00**		

*p<0.05, **p<0.001.

[†]Adjusted on the covariates: age, region, alcohol consumption, smoking status, close relative with cancer & living in couple

[‡] Calculated using a two way interaction term composed of socioeconomic variable of interest and survey year dummy variable (2010 vs. 2006

Table 5. Association between socio-economic variables and the probability of FOBT participation in 2005 and 2010: unadjusted[†] and adjusted Odds Ratios

	FOBT 2005 (n=1222)				FOBT 2010 (n=1425)				
Socio-economic variable	**Unadjusted OR**	(95% CI)	**Adjusted OR**	(95% CI)	**Unadjusted OR**	(95% CI)	**Adjusted OR**	95% CI	***p*-trend[‡] 2005-2010**
Occupation									0.372
Manager	**1.00**		**1.0**		**1.00**		**1.0**		
Farmer	**0.57**	(0.29, 1.10)	**0.61**	(0.31, 1.21)	**0.97**	(0.46, 2.05)	**0.72**	(0.32, 1.61)	
Self-employed	**0.78**	(0.46, 1.31)	**0.70**	(0.41, 1.20)	**0.82**	(0.51, 1.31)	**0.80**	(0.48, 1.32)	
Professional	**0.83**	(0.57, 1.23)	**0.90**	(0.60, 1.34)	**0.85**	(0.60, 1.20)	**0.94**	(0.65, 1.37)	
Employee	**0.66**	(0.45, 0.96)*	**0.83**	(0.60, 1.24)	**0.78**	(0.54, 1.12)	**0.99**	(0.66, 1.50)	
Manual worker	**0.67**	(0.44, 1.03)	**0.69**	(0.44, 1.07)	**0.66**	(0.45, 0.96)*	**0.63**	(0.42, 0.96)*	
Other	**0.76**	(0.39, 1.46)	**0.85**	(0.42, 1.73)	**0.58**	(0.36, 0.95)*	**0.71**	(0.41, 1.23)	
Income									0.114
>€1500	**1.00**		**1.00**		**1.00**		**1.00**		
€1000-1500	**0.85**	(0.61, 1.18)	**0.93**	(0.66, 1.31)	**0.94**	(0.67, 1.31)	**1.00**	(0.68, 1.46)	
<€1000	**0.63**	(0.42, 0.94)*	**0.62**	(0.39, 0.97)*	**0.89**	(0.62, 1.29)	**0.99**	(0.64, 1.52)	
RII	**0.54**	(0.31, 0.93)*	**0.70**	(0.38, 1.28)	**0.83**	(0.49, 1.41)	**0.99**	(0.52, 1.86)	0.137
Education level									0.441
Superior BAC	**1.00**		**1.00**		**1.00**		**1.00**		
BAC	**0.79**	(0.50, 1.24)	**0.85**	(0.53, 1.34)	**1.21**	(0.81, 1.83)	**1.25**	(0.80, 1.95)	
Inferior BAC	**0.77**	(0.58, 1.04)	**0.75**	(0.55, 1.02)	**0.99**	(0.74, 1.34)	**0.94**	(0.68, 1.30)	
RII	**0.67**	(0.41, 1.09)	**0.69**	(0.42, 1.14)	**0.90**	(0.56, 1.45)	**0.81**	(0.48, 1.35)	0.466
Employment									0.800
Employed	**1.00**		**1.00**		**1.00**		**1.00**		
Unemployed	**0.86**	(0.40, 1.88)	**1.09**	(0.49, 2.40)	**0.68**	(0.37, 1.27)	**0.86**	(0.45, 1.66)	
Inactive	**1.45**	(1.12, 1.88)*	**1.18**	(0.83, 1.67)	**1.58**	(1.25, 1.99)**	**1.14**	(0.82, 1.58)	
Complementary health insurance									0.485
Yes	**1.00**		**1.00**		**1.00**		**1.00**		
No	**0.50**	(0.25, 0.97)*	**0.53**	(0.26, 1.05)	**0.65**	(0.40, 1.05)	**0.81**	(0.47, 1.38)	
Basic health insurance									0.388
Yes	**0.70**	(0.43, 1.16)	**0.75**	(0.47, 1.22)	**1.03**	(0.69, 1.54)	**1.06**	(0.68, 1.65)	
No	**1.00**		**1.00**		**1.00**		**1.00**		

*p<0.05, **p<0.001.

[†]Adjusted on the covariates: age, region, alcohol consumption, smoking status, close relative with cancer & living in couple

[‡] Calculated using a two way interaction term composed of socioeconomic variable of interest and survey year dummy variable (2010 vs. 2006

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found**: Included, please see page 1 and 2.**
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported **Included, please see 5 and 6**
Objectives	3	State specific objectives, including any prespecified hypotheses**. Included please see page 6, last sentence.**
Methods		
Study design	4	Present key elements of study design early in the paper. **Included, please see page 7, study population section, first paragraph.**
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection. **Included, please see page 7, study population section, second paragraph.**
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants**. Included, please see page 7, study population section, first paragraph.**
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable**. Included, please see page 8, Measures section.**
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group. **Included, please see page 8, Measures section.**
Bias	9	Describe any efforts to address potential sources of bias. **Included, please see page 7, second sentence, study population section, and page 8, last paragraph, Measures section.**
Study size	10	Explain how the study size was arrived at**. Included, please page 7, second paragraph, study population section.**
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why**. Included, please page 8, Measures sections.**
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding **Included, please page Statistical Analysis section pages 9-10**
		(*b*) Describe any methods used to examine subgroups and interactions **Included,**

	please statistical analysis section, second and third paragraphs.
(*c*) Explain how missing data were addressed. **Included, please see page 7, study population section, second paragraph.**	
(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy**. Included, please see page 8, Measures section, last paragraph.**	
(*e*) Describe any sensitivity analyses. **N/A.**	

Continued on next page

Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed **YES**
		(b) Give reasons for non-participation at each stage **YES**
		(c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders **YES**
		(b) Indicate number of participants with missing data for each variable of interest **YES**
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures **YES**
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included **YES**
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period **YES**
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results	18	Summarise key results with reference to study objectives **YES**
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias **YES**
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence **YES**
Generalisability	21	Discuss the generalisability (external validity) of the study results **YES**
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based **YES**

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

Temporal trend in socio-economic inequalities in the uptake of cancer screening programs in France between 2005 and 2010: Results from the Cancer Barometer surveys

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ABSTRACT

Objectives: Cancer screening is a form of secondary prevention for a disease which is now the leading cause of death in France. Various socio-economic-indicators have been identified as potential factors for disparities in breast, cervical and colorectal cancer screening uptake. We aimed to identify the socioeconomic-inequalities which persisted in screening uptake for these cancers, and to quantify these disparities over a 5-year period.

Setting: The Cancer-Barometer was a population-based-survey carried out in 2005 and 2010 in France.

Participants: A randomly selected sample of participants aged 15 to 85 years (n=3820 in 2005 and n=3727 in 2010) were interviewed on their participation in breast, cervical and colorectal cancer screening programs and their socioeconomic profile.

Primary and secondary outcome measures: For each type of screening-program, we calculated participation rates, odds ratios (OR) and relative inequality indices (RII) for participation, derived from logistic regression of the following socioeconomic variables: income, education, occupation, employment and health insurance. Changes in participation between 2005 and 2010 were then analyzed.

Results: Participation rates for breast and colorectal screening increased significantly along the majority of socioeconomic categories, whereas for cervical cancer screening there were no significant changes between 2005 and 2010. RIIs for income remained significant for cervical smear in 2005 (RII=0.25, 95% CI 0.13-0.48) and in 2010 (RII=0.31, 95% CI 0.15-0.64). RIIs for education in mammography (RII=0.43, 95% CI 0.19-0.98) and cervical smear (RII=0.36, 95% CI 0.21-0.64) were significant in 2005 and remained significant for cervical smear (RII=0.40, 95% CI 0.22-0.74) in 2010.

Conclusions: There was a persistence of socioeconomic inequalities in uptake of opportunistic cervical cancer screening. Conversely, organized screening-programs for breast and colorectal cancer saw a reduction in relative socioeconomic inequalities, even though the results were not statistically significance. The findings suggest that organized-cancer-screening programs may have the potential to reduce socio-economic disparities in participation.

Key words: cancer screening, breast cancer, cervical cancer, social inequalities, cancer epidemiology

Strengths and limitations of this study

- First study to examine temporal changes in inequalities for cancer screening uptake in France using relative inequality index.
- Benefits from datasets of two identical questionnaires on cancer screening uptake, taken 5 years apart, using two comparable population samples, hence minimizing information bias.
- Evolution in the format of colorectal screening program in terms of technique and age limits may have led to measured differences in uptake between 2005 and 2010.
- Residents of nursing homes and other medical institutions without a personal telephone line were excluded from the survey, limiting the generalizability of the findings.
- Relatively small number for certain socio-economic strata, reducing therefore the precision of some estimates.

INTRODUCTION

Screening for cancer is an important form of secondary prevention for a disease which is now leading cause of death in France and worldwide [1]. The 2008 European report on cancer recommends that health systems focus their resources on cancer prevention and early detection rather than treatment alone, as the global disease burden of cancer threatens to become unsustainable in terms of financial costs, pressure on services, follow-up of patients and delivery of care [2].

To date, many European countries have rolled out screening programs for breast, colorectal and cervical cancer via mammography, faecal occult blood test (FOBT) and cervical smear respectively [3, 4]. However, for these screening programs to have a significant effect on reducing cancer mortality, they require a minimum level of participation among the eligible population; for instance 70% for mammography, and 50% for FOBT [5].

We reviewed several publications from France, UK, USA, Italy, Denmark, Korea and Argentina, which identified variables shown to have a significant effect on cancer screening uptake [6-19]. For breast cancer screening, various different social and economic variables were found to have a positive effect on uptake, including employment, ~~living in a couple,~~ higher occupation class, higher education level, income, private health insurance, car/home ownership ~~and rural residency~~. However, no single variable was consistently observed across studies except for participation in other screening programs [7, 18]. For cervical cancer screening, the variables identified as having a significant positive effect on uptake were more numerous, and notably consistent for income [7, 11, 17], higher education level [10-12, 17, 18], employment [6, 12, 18, 19] and private health insurance [6, 7, 18]. ~~For colorectal screening, general practitioners' (GP) consultation [6, 7, 18, 19] was consistently shown to have a significant positive effect on uptake of screening across the studies, as well as income [14, 16, 18].~~ For colorectal screening, income was consistently shown to have a

significant positive effect on uptake of screening across the studies [14, 16, 18]. However, it remains unclear whether the effect of these socio-economic variables on participation rates in screening programs persists over time.

Only one study drawn from the 2006, 2008 and 2010 French Healthcare and Health Insurance surveys has examined the temporal evolution in breast, cervical and colorectal cancer screening uptake in France to date [6]. This study conducted among 10 000 participants found that those classified as unskilled workers were ~~less~~ more likely to have not undergone cervical cancer screening (OR = 1.64 [1.38-1.95]) when compared to those with an intermediate profession. The results also showed that women without (OR = 2.05 [1.68-2.51]) or receiving free complementary health insurance (OR = 1.79 [1.36-2.37]) were ~~less~~ more likely to have not undergone breast cancer screening when compared to those with a private complementary health insurance. In this study, the authors found that inequalities for participation in breast and colorectal cancer screening persisted over the study period from 2006 to 2010 [6]. Thus, we believe that there is a need to re-examine how these trends may have evolved with respect to expansion in the coverage and awareness of organized cancer screening programs. The third French National Cancer Plan for the 2014-2019 period has identified early detection of cancers as a primary priority [20]. Within this goal is the reduction of inequalities associated with cancer diagnosis, with the hope that it subsequently reduces mortality rates. Any widening or reduction in socio-economic inequalities in the uptake of screening programs that are identified may then be used to direct future policy of the French national cancer control plan, which specifically seeks to address this issue [20]. We aim therefore in the present study to identify the socio-economic inequalities which persist for uptake of breast, cervical and colorectal cancer screening, and to quantify these disparities over a 5 year period in France.

MATERIALS AND METHODS

Study population

We used data, obtained by formal permission, from the Cancer Barometer surveys, two telephone surveys on cancer-related knowledge, attitudes and practices conducted by the French National Institute for Prevention and Health (now part of Santé Publique France). Both surveys were carried out on a representative random sample of the general French population aged over 16 years old for the 2005 survey and aged 15–85 years old for the 2010 survey. A two-stage random sampling design was used. Residents of nursing homes or other medical institutions who did not possess a personal telephone line were not included in the samples. Private households with telephones were included in the sample. The first sampling step was household selection (by phone number). Within each selected household, one French speaking person aged 15–85 was randomly selected using the "next birthday" method. The study protocol included a formal request to participate, explaining the objectives of the study that was delivered by mail before the first telephone call. Informed consent was obtained at the start of the telephone interview, in accordance with the guidelines of the French Data Protection Authority (CNIL). The interviews were conducted using a computer-assisted telephone interview (CATI) system.

In order to obtain adequate statistical power for measuring associations between variables and changes in participation rates along smaller levels, a sample size of between 3500 and 4000 was deemed appropriate. The 2005 Cancer Barometer sample was comprised of 4046 participants aged over 16 years interviewed between April and June 2005 [18]. There were 226 individuals with missing observations in the 2005 Cancer Barometer sample, notably for all 3 of the dependent variables, and 7 out of 10 of the covariates and independent variables. These individuals terminated the survey prematurely, and were thus removed from the analysis as their data was non-contributive, leaving 3820 participants in the sample population. Females (51.5%) responded more

often than males (48.5%) and mean age of interviewees was 46.7 years. The 2010 Cancer Barometer sample was comprised of 3727 participants aged 15 to 85 interviewed during the first semester of 2010 [19]. The mean age was 44.6 years and the majority of participants were also female (52.0%vs. 48.0%). The response rates for the 2005 and 2010 Cancer Barometers were 51.2% and 47.0%, respectively.

Measures

Socio-economic indicators (independent variables) were as follows: education level (inferior, equal to or superior to baccalauréat (high-school diploma), employment status (employed, unemployed, and inactive), occupational class (farmer, trader, manager, professional, employee, manual worker, other), monthly income (below €1000, €1000-1500, above €1500) and health insurance (private complementary vs. basic insurance coverage). The outcome variables were participation in breast, cervical and colorectal cancer screening programs (dependent variables). For breast cancer screening, participants aged over 40 years were asked if they had undergone mammography within the previous 2 years. For cervical cancer screening, participants aged over 20 years were asked if they had undergone a cervical smear within the previous 3 years. For colorectal cancer screening, participants aged 50-74 years were asked if they had undergone a faecal occult blood test (FOBT) within their lifetime. Covariates included gender, age, smoking status, alcohol consumption, region, living in a couple and having a close relative with cancer. For the calculation of screening participation rates, we added filters to select the target population eligible for each of the 3 different screening programs. Breast screening by mammography (n=1546): female gender and 49<age<75. Cervical screening by cervical smear (n=3085): female gender and 24<age<66. Colorectal screening by FOBT (n=2647): both genders where 49<age<75.

The weighting was based on the data of the 1999 and 2008 Employment Survey of the French population [21], taking into account age, gender, region, education level and number of persons per

household [18]. This allowed us to effectively calculate age-adjusted standardized rates for screening participation, in addition to later adjusting the regression models on the covariates mentioned.

Statistical analysis

We created a pooled dataset of the two surveys conducted in 2005 and 2010. We calculated age-adjusted screening rates (AAR) for each stratum using the weighting provided by the INPES. The temporal evolution in the participation rate along each stratum between 2005 and 2010 was examined by adding an interaction term with the year of the survey. The disparity within each socio-economic variable was calculated as the absolute difference between the AAR for the highest and lowest group within an ordinal or binary variable for the given year.

Odds ratios (OR) derived from multiple logistic regression of screening participation on each socio-economic variable separately were used as a measure of participation likelihood for each stratum of the 6 socio-economic variables. The model was adjusted on the covariates: age, gender (colorectal screening only), region, alcohol, smoking, living in couple and close relative with cancer. For categorical variables, the higher socio-economic position was used as the reference group. The trend of disparities within each socioeconomic variable for each survey was then estimated and compared using a two way interaction term composed of socioeconomic variable of interest and survey year dummy variable (2010 vs. 2006), in order to be consistent with the methodology of previous studies on the topic [22, 23].

For ordinal variables of income and education level, we calculated the Relative Inequality Index (RII) as a measure of health inequality as described by Mackenbach and Kunst [24]. Previous studies on health inequalities, including breast cancer screening uptake [4, 9], employed a similar methodology for examining temporal evolutions along ordered socio-economic strata [23, 25]. The trend of RII for each survey was estimated and compared using a two way interaction term

composed of socioeconomic variable of interest and survey year dummy variable (2010 vs. 2006). The RII is a regression-based measure that summarizes the association between two variables. It is computed by ranking income and education values on a scale from the lowest, which is 0, to the highest, which is 1. Each income or education level value covers a range on this scale that is proportional to the number of participants who held that value and is given a new value on the scale corresponding to the cumulative midpoint of its range. The RII resembles relative risk in that it compares the probability of cancer screening uptake at the extremes of income and educational levels, but is estimated using the data on all income and education values and is weighted to account for the distribution of these values. Here the RII was fitted using logistic regression models. An RII of 0.5 for example implies that participants in the most deprived group (those with lower incomes and educations levels) had a 50% lower probability of cancer screening uptake when compared to those in the least deprived group (those with higher incomes and education levels). All statistical analysis was performed using SAS version 9.2.

RESULTS

Table 1 presents the demographic and socio-economic characteristics of the study populations. The overall participation rates among the eligible populations for breast, cervical and colorectal cancer screenings are shown in Table 2. Chi-squared tests for the change in participation rates along each socio-economic stratum between 2005 and 2010 are also included. For mammography, participation rates increased significantly ($p<0.05$) along all socio-economic strata, with the exception of farmers, managers, manual workers, unemployed, those with basic health insurance and education level superior to baccalauréat. For FOBT, participation rates increased significantly along all socio-economic strata between 2005 and 2010, with the exception of those unemployed or occupation classified as other. For cervical smear there were no significant changes

in participation rates along any of the socio-economic strata, except for those without complementary health insurance, which increased significantly from 52.51% to 71.0% (p=0.017).

Table 3 shows the results of the logistic regression models for mammography participation on each socio-economic variable separately, adjusted for covariates. In 2005, farmers, self-employed, employees and manual workers showed significantly reduced participation compared to managers/executives, whereas in 2010 only the association in manual workers remained significant. In 2005, those with an education level inferior to baccalauréat (OR=0.57, 0.35-0.95) showed significantly reduced participation compared to those superior to baccalauréat, which became non-significant in 2010 (OR=1.04, 0.53-2.05).

Table 4 shows the results of the regression model for cervical smear participation for each socio-economic variable. In 2005, significantly reduced participation was observed for self-employed and manual workers, which became non-significant for both in 2010. In 2005, there was significantly reduced participation for those earning <€1000 and €1000-€1500, which remained significant in 2010 for those earning <€1000 (OR=0.47, 95% CI 0.29-0.76). An education level inferior to baccalauréat showed significantly lower participation in both 2005 and in 2010. In 2005, being unemployed or inactive significantly reduced participation, and remained significant for both in 2010. The odds ratio for cervical smear participation changed significantly (p=0.014) for those without complementary health insurance from 0.29 (95% CI 0.17-0.49) in 2005 to 0.64 (95% CI 0.38-1.08) in 2010. Having only basic health insurance was significantly associated with reduced participation in both periods.

Table 5 shows the logistic regression results for FOBT participation on each socio-economic variable. For occupation, manual workers (OR=0.63, 95% CI 0.42-0.96) showed significantly reduced participation in 2010. Odds ratios for all other occupations showed reduced participation compared to managers, but at a non-significant level in 2005 and 2010. Those earning <€1000

showed reduced participation in 2005 (OR=0.62, 95% CI 0.32-0.97), which became non-significant in 2010. There were no significant temporal changes in any of the odds ratios for participation in breast or colorectal cancer screening between 2005 and 2010.

The regression of screening participation on income distribution produced RIIs which can be found in Tables 3-5. The results showed significant inequalities for cervical smear (RII=0.25, 95% CI 0.13-0.48) in 2005, but not for mammography (RII=0.47, 95% CI 0.19-1.29) or FOBT (RII= 0.70, 95% CI 0.38-1.28). In 2010 the income-based RII remained significant for cervical smear (RII=0.31, 0.15-0.64). For education, mammography (RII=0.43, 95% CI 0.19-0.98) and cervical smear (RII=0.36, 95% CI 0.21-0.64) showed significant inequalities in 2005, whereas the RII for FOBT was non-significant (RII=0.69, 95% CI 0.42-1.14). In 2010, the education-based RII for mammography became non-significant (RII=0.80, 95% CI 0.26-2.50), whereas the RII for cervical smear remained significant (RII=0.40, 95% CI 0.22-0.74). The p-trend for the temporal change in the RIIs (adjusted model) measured by interaction term between 2005 and 2010, was non-significant for all 3 screening programs for income and education level.

DISCUSSION

Our objective was to identify the socio-economic inequalities which persisted for uptake of breast, cervical and colorectal cancer screening, and to quantify these disparities between the 2005 and 2010. In absolute terms, a significant increase in participation rates was observed for most socio-economic strata for mammography and for FOBT between 2005 and 2010. Cervical cancer screening however saw no significant change in participation rates between 2005 and 2010 (except for those without complementary health insurance). A similar trend was observed when relative inequalities were considered. It should be noted that some of these inequalities were persistent between 2005 and 2010, even though formal statistical tests for trend were generally not significant.

Findings in the context of the literature

We found only one study that has examined the temporal evolution in breast, cervical and colorectal cancer screening uptake in France to date [6]. However, an important difference between our study and that study conducted by Sicsic and Franc relies on their objectives and consequently on the methods used to reach them. The study by Sicsic and Franc aimed to analyze the obstacles to and levers for breast, cervical, and colorectal cancer screening uptake and their trends over time, whereas the aim of our study was to identify the socio-economic inequalities which persist for uptake of breast, cervical and colorectal cancer screening, and to quantify these disparities over a 5 year period. Thus, Sicsic and Franc pooled their three samples but did not conduct direct comparisons of associations between indicators of socioeconomic position and uptake of cancer screenings between periods.

The sole point of comparison between the two studies concerns the overall participation in screening programs. Sicsic and Franc found that the screening rate for breast cancer decreased between 2006 and 2010, from 77.6% in 2006 to 74.0% in 2010", but the difference was not statistically significant. Although, we found an increase in participation rates for breast cancer screening, it was not statistically significant at the level of 5%. They also found that colorectal cancer screening uptake increased significantly between 2006 and 2010, from 18.2% in 2006 to 38.9% in 2010. This is consistent with our result showing that colorectal cancer screening uptake significantly increased from 34.0% in 2005 to 51% in 2010. Finally, they found that the screening rate for cervical cancer significantly decreased from 75.3% in 2006 to 71.9% in 2010. For cervical cancer, we found that the rate was stable between 2006 (79.7) and 2010 (81.4). In definitive, differences in sampling, sample sizes, number of data collection phases, and in desirability bias may explain these differences in participation rates. It should be also noted that the study by Sicsic and Franc was based on three surveys carried out in 2006, 2008 and 2010, with therefore a two-year

interval, whereas the Cancer Barometer survey was conducted at two points in time in 2005 and 2010

~~It is encouraging to note the significant increase in participation rates for most socio-economic strata for mammography between 2005 and 2010. This effect was not demonstrated in a French study by Sicsic and Franc in 2006, 2008 and 2010, which showed a non-significant slight decrease in mammography participation rates over time [6]. This study did however show a large increase in colorectal cancer screening rates, in line with our findings. Cervical cancer screening however saw no significant change in participation rates between 2005 and 2010 (except for those without complementary health insurance), while Sicsic and Franc showed an overall decrease in participation rates from 2006 to 201~~0. Our study confirmed significantly reduced participation for manual workers in breast and colorectal screening and for those with only basic health insurance in breast and cervical screening in 2010. This is consistent with the study by Sicsic and Franc which showed reduced participation in all 3 screening programs for manual workers and those with only basic health insurance.

~~Several factors may explain why some of our findings differ from those by Sicsic et al. The study by Sicsic et al. was based on three surveys carried out in 2006, 2008 and 2010, with therefore a two-year interval, whereas the Cancer Barometer survey was conducted at two points in time in 2005 and 2010. Another important difference between the two studies relies on their objectives and consequently on the methods used to reach them. The study by Sicsic and Franc aimed to analyze the obstacles to and levers for breast, cervical, and colorectal cancer screening uptake and their trends over time, whereas the aim of our study was to identify the socio-economic inequalities which persist for uptake of breast, cervical and colorectal cancer screening, and to quantify these disparities over a 5 year period. Thus, Sicsic and Franc pooled their three samples and did not~~

~~conduct direct comparisons of associations between indicators of socioeconomic position and uptake of cancer screenings between periods.~~

Breast and colorectal cancer screening programs saw the absolute differences in participation rates reduced over time for all socio-economic variables in our study, with the exception of employment and basic health insurance. ~~Sicsic and Franc found that disparities in participation did not decrease for mammography or FOBT screening from 2006 to 2010 [6].~~ An American study by Kim et al. showed the disparity in mammography participation based on income remained unchanged, while the disparity based on education decreased from 2000 to 2005 [9]. Cervical cancer screening however saw a persisting disparity in participation rates for the majority of socio-economic variables in our study, consistent with the results of De Maio et al. and Sicsic and Franc [6, 17].

The relative inequalities for income and education decreased for breast and colorectal cancer screening in our study, albeit non-significantly. This is somewhat consistent with DeMaio et al., which showed a reduction in the RII for breast cancer screening from 2005 to 2009 [17]. In the study by Kim et al., the income-based relative inequalities tended to decrease slightly, while those for education remained constant over time [9]. The relative inequalities for cervical cancer screening persisted for both income and education from 2005 to 2010 in our study, both remaining statistically significant. This is partially consistent with the De Maio et al., where the social gradient decreased for income and increased for education between 2005 and 2010 [17].

Interpretation of results

Breast and colorectal screening programs are organized at a national level and differences in absolute participation rates and relative inequalities decreased over time for all socio-economic variables. For both breast and colorectal screening, the odds ratios for manual workers showed reduced participation compared to managers/executives in 2010. Education and occupation are

strongly correlated, with manual workers having a higher proportion of participants with an educational level inferior to baccalauréat (85%) than any other occupational category in 2010. Thus they may have been less aware of the health marketing campaigns for colorectal cancer screening and the recommendation for FOBT, due to the negative effect of lower education on health literacy [14, 26, 27].

Cervical cancer remains without a nationally organized screening program in France. It is the duty of doctors to organize and falls to the individual to pay for opportunistic screening via cervical smear test. The lack of a nationally organised screening program may impose significant financial, educational and cultural barriers to screening uptake among certain sections of the French population. The financial costs for a consultation and laboratory processing of the screening test may deter those with only basic health insurance, as public reimbursement covers only 70% of the cost [28]. This may account for the persistence of the observed differences in participation rates and large RIIs. Improving the awareness, affordability and access to cervical cancer screening should be prioritised in order to increase participation rates and reduce socio-economic disparities.

Limitations and strengths of the study

Our study used two almost identical datasets to construct a temporal analysis of participation in screening programs in France between 2005 and 2010. The use of relative inequality indices to measure the evolution of socio-economic inequalities in our study is the first to employ this methodology among a French population for cancer screening. The comparability of the study populations minimized selection bias and the conservation of the questionnaire format minimized information bias.

The study still has several limitations however. It shares the usual shortcomings of phone surveys. There is a potential selection bias, as residents of nursing homes or other medical institutions who did not possess a personal telephone line were not included in the samples. The

study includes only those who are French speakers, excluding individuals unable to answer fluently in French. There was no available data on ethnicity or nationality of participants in the study, which may have been an important source of confounding or effect modification. The exclusion of the above subpopulations, which are likely to be more socio-economically disadvantaged, may have overestimated the screening participation rates in our study.

Our study used two separate sample populations, whose distributions in Table 2 differed significantly for all of the socio-economic indicators and several covariates. The difference in sample distributions may have accounted for the observed differences in screening participation rates. Thus, we cannot rule out that reductions observed in inequalities over time are not simply due to changes in socioeconomic distributions rather than an actual reduction in social inequalities in screening participation.

Changes in screening policies concerning age limits, screening techniques and regional access left the 2005 and 2010 Cancer Barometers not directly comparable for certain programs. The question of screening participation for colorectal cancer was therefore limited to lifetime use of FOBT. Organized cervical screening was available in 13 regions in 2009, a source of regional variation not present in 2005. Some screening techniques are more memorable to patients, due to the invasiveness of the screening technique or the duration of the screening intervals, which may have led to recall bias.

The respective analytical sample sizes in 2005 and 2010 for breast (n=742, n=804), cervical (n=1571, n=1514) and colorectal (n=1222, n=1425) cancer screening may have been too small to capture disparities along socio-economic strata, leading to false observations and conclusions. Missing observations for each variable accounted for less than 5% of the total population, except for the variable income (16.3% missing in 2005 and 9.3% in 2010). This might have limited the precision of certain estimates, producing participation rates with large standard errors and odds

ratios with large confidence intervals. We undertook multiple comparisons in our study. Thus, we cannot exclude that some of the results we have observed are due to chance.

Conclusion

The findings suggest that organized cancer screening programs may have the potential to reduce socio-economic disparities in participation.

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Competing interest statement

All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf and declare: no support from any organisation for the submitted work; no financial relationships with any organisations that might have an interest in the submitted work in the previous three years; no other relationships or activities that could appear to have influenced the submitted work.

Contributors

HN conceived the study, advised on methodology, reviewed the results of statistical analyses and supervised the final edit of the manuscript. DK reviewed the background literature, run statistical analyses and drafted the manuscript. CE, CL, PA provided advice on methodology and statistical analyses. CL & PA directed the data collection. All authors contributed to the final draft of this manuscript.

Data sharing statement

All data presented in this manuscript came from 2 original datasets of the 2005 and 2010 Cancer Barometer surveys. The original files can be requested by contacting Santé Publique France (formerly INVS and INPES) via Pierre Arvidson (pierre.arwidson@santepubliquefrance.fr) or Christophe Léon (christophe.leon@santepubliquefrance.fr).

Table 1. Standardized† distribution of study populations for 2005 and 2010 Cancer Barometer surveys, p-value for Chi-squared test

Variables	Barometer 2005 (n=3820)		Barometer 2010 (n=3727)		p-value
	n	%	n	%	
Gender					0.660
Male	1854	48,5	1790	48,0	
Female	1966	51,5	1937	52,0	
Region					0.976
Ile-de-France	701	18,4	696	18,7	
West Paris basin	380	10,0	348	9,3	
East Paris basin	305	8,0	290	7,8	
North	257	6,7	238	6,4	
West	508	13,3	504	13,5	
East	334	8,8	321	8,6	
South West	414	10,9	412	11,1	
South East	455	12,0	447	12,0	
Mediterranée	457	12,0	471	12,6	
Occupation					<0.001
Farmer	117	3,1	81	2,2	
Self-employed/craftsman	220	5,8	270	7,2	
Manager/executive	589	15,4	595	16,0	
Professional	773	20,3	914	24,5	
Employee/office worker	970	25,4	829	22,3	
Manual worker	642	16,8	839	22,5	
Oher	506	13,3	199	5,3	
Education level					<0.001
Inferior BAC*	1946	52,0	2270	61,2	
BAC	651	17,4	635	17,1	
Superior BAC	1146	30,6	803	21,7	
Monthly Income					<0.001
<€1000	414	13,2	399	12,1	
€1000-1500	663	21,0	499	15,1	
>€1500	2075	65,8	2401	72,8	
Employment					<0.001
Employed	2146	56,2	1851	49,7	
Unemployed	177	4,6	260	7,0	
Inactive	1497	39,2	1615	43,3	
Alcohol consumption					<0.001
Yes	3430	89,8	3195	85,7	
No	389	10,2	532	14,3	
Smoking status					<0.001
Yes	964	25,2	1195	32,1	
No	2856	74,8	2532	67,9	
Close Relative with cancer					0.950
Yes	2366	62,1	2198	62,1	
No	1446	37,9	1339	37,9	
Living in couple					0.071
Yes	2465	64,6	2333	62,6	
No	1351	35,4	1394	37,4	
Complementary Health Insurance					<0.001
Yes	3518	92,6	3210	89,6	
No	282	7,4	375	10,5	
Basic Health Insurance					0.003
Yes	361	10,2	441	12,4	
No	3182	89,8	3109	87,6	

* BAC = Baccalauréat (high-school diploma)

†Weighted by age, gender, region and educational level according to standard population of the 1999 and 2008 Employment Surveys (INSEE)

Table 2. Standardized† participation rates for eligible participants in 3 screening programs, Chi-squared test for 2005-2010, *p*-trend

Socio-economic variable	Mammography			Cervical smear			FOBT		
	participation rate (%) ± SE			participation rate (%) ± SE			participation rate (%) ± SE		
	2005 (n=742)	2010 (n=804)	Chi2 *p*-value	2005 (n=1571)	2010 (n=1514)	Chi2 *p*-value	2005 (n=1222)	2010 (n=1425)	Chi2 *p*-value
Overall	72.1	88.3		79.7	81.4		34.0	51.6	
Occupation									
Farmer	62.49 ±8.24	87.64 ±8.81	0.148	75.61 ±7.28	80.39 ±11.63	0.739	26.97 ±6.69	56.50 ±10.82	0.006
Self-employed	63.70 ±9.46	85.96 ±5.37	0.027	71.02 ±7.00	77.92 ±6.89	0.438	33.47 ±5.61	52.30 ±5.75	0.009
Manager	85.50 ±4.04	91.45 ±2.50	0.262	85.15 ±2.51	83.88 ±3.05	0.740	39.33 ±3.89	57.33 ±3.31	0.0003
Professional	74.87 ±3.74	87.82 ±2.95	0.004	84.31 ±1.95	88.17 ±1.68	0.153	35.04 ±3.21	53.32 ±2.79	<0,0001
Employee	68.76 ±3.00	90.58 ±1.98	<0.0001	78.05 ±1.81	81.52 ±2.06	0.170	29.92 ±2.63	51.07 ±3.54	<0,0001
Manual worker	64.52 ±6.01	76.02 ±5.29	0.161	74.70 ±3.96	75.00 ±4.22	0.956	30.29 ±3.74	46.95 ±4,23	0.001
Other	69.37 ±6.19	83.70 ±5.28	0.097	81.14 ±4.21	62.94 ±6.53	0.010	32.87 ±6.20	43.84 ±6.92	0.204
Education level									
Inferior BAC	67.80 ±2.29	86.26 ±1.79	<0.0001	75.20 ±1.77	76.88 ±1.97	0.484	31.55 ±1.82	51.06 ±2.06	0
BAC	71.86 ±5.71	93.63 ±2.15	0.0003	83.59 ±2.47	86.42 ±2.03	0.385	32.07 ±4.46	56.06 ±3.58	<0,0001
Superior BAC	80.17 ±3.49	87.34 ±2.56	0.153	84.27 ±1.65	86.81 ±1.67	0.318	37.39 ±3.27	51.23 ±2.92	0.002
Difference	*12.37*	*1.08*		*9.07*	*9.93*		*5.84*	*0.17*	
Income									
<€1000	58.45 ±4.48	82.62 ±3.92	0.001	64.78 ±4.01	64.81 ±4.70	1	27.02 ±3.55	49.40 ±4.79	0.0001
€1000-1500	68.62 ±4.19	84.95 ±3.57	0.006	72.43 ±2.96	78.81 ±3.49	0.161	33.29 ±3.35	50.61 ±4.33	0.001
>€1500	76.21 ±2.65	89.57 ±1.59	<0.0001	85.21 ±1.25	84.96 ±1.36	0.885	37.07 ±2.23	52.29 ±1.96	<0,0001
difference	*17.76*	*6.95*		*20.43*	*20.15*		*10.05*	*2.89*	
Complementary health insurance									
Yes	72.09 ±1.84	88.08 ±1.38	<0.0001	81.77 ±1.08	81.83 ±1.29	0.964	33.63 ±1.53	52.31 ± 1.64	<0,0001
No	48.35 ±9.53	78.06 ±7.49	0.013	52.51 ±6.04	71.00 ±5.67	0.017	20.10 ±5.58	41.51 ±7.71	0.011
difference	*23.76*	*10.02*		*29.26*	*10.83*		*13.53*	*10.80*	
Basic health insurance									
Yes	66.12 ±7.38	69.98 ±8.60	0.694	67.20 ±4.70	67.22 ±5.47	1	26.23 ±4.56	52.75 ±6.93	0.0001
No	70.99 ±1.93	88.72 ±1.28	<0.0001	81.52 ±1.12	82.87 ±1.24	0.399	33.83 ±1.60	52.06 ±1.64	<0,0001
difference	*4.87*	*18.74*		*14.32*	*15.65*		*7.60*	*0.69*	
Employment									
Employed	76.23 ±3.07	89.0 ±2.21	0.001	83.75 ±1.21	86.56 ±1.34	0.097	28.37 ±2.42	45.11 ±2.56	<0,0001
Unemployed	66.26 ±9.44	84.1 ±8.73	0.176	66.00 ±5.25	72.88 ±5.23	0.304	25.48 ±6.60	35.91 ± 9.21	0.308
Inactive	68.58 ±2.32	86.79 ±1.75	<0.0001	72.72 ±2.51	71.15 ±2.73	0.665	36.51 ±1.93	56.48 ±2.03	<0,0001

†Weighted by age, gender, region and educational level according to standard population of the 1999 and 2008 Employment Surveys (INSEE)

Table 3. Association between socio-economic variables and the probability of participation in mammography in 2005 and 2010: unadjusted[†] and adjusted odds ratios

	Mammography 2005 (n=742)				Mammography 2010 (n=804)				
Socio-economic	**Unadjusted**		**Adjusted**		**Unadjusted**		**Adjusted**		***p*-trend[‡]**
variable	**OR**	(95% CI)	**OR**	(95% CI)	**OR**	(95% CI)	**OR**	(95 % CI)	**2005-2010**
Occupation									0.521
Manager	**1.00**		**1.0**		**1.00**		**1.0**		
Farmer	**0.28**	(0.10, 0.77)*	**0.33**	(0.12, 0.92)*	**0.66**	(0.08, 5.45)	**0.64**	(0.07, 5.54)	
Self-employed	**0.30**	(0.11, 0.81)*	**0.33**	(0.12, 0.93)*	**0.57**	(0.18, 1.86)	**0.60**	(0.18, 2.00)	
Professional	**0.51**	(0.23, 1.10)	**0.53**	(0.24, 1.18)	**0.67**	(0.26, 1.72)	**0.66**	(0.25, 1.74)	
Employee	**0.37**	(0.18, 0.77)*	**0.39**	(0.19, 0.82)*	**0.90**	(0.36, 2.26)	**1.13**	(0.43, 2.95)	
Manual worker	**0.31**	(0.13, 0.74)*	**0.34**	(0.14, 0.84)*	**0.30**	(0.11, 0.78)*	**0.34**	(0.12, 0.94)*	
Other	**0.38**	(0.16, 0.95)*	**0.45**	(0.17, 1.14)	**0.48**	(0.16, 1.47)	**0.59**	(0.18, 1.95)	
Income									0.775
>€1500	**1.00**		**1.00**		**1.00**		**1.00**		
€1000-€1500	**0.68**	(0.42, 1.11)	**0.83**	(0.50, 1.39)	**0.66**	(0.34, 1.27)	**1.04**	(0.49, 2.20)	
<€1000	**0.44**	(0.26, 0.73)*	**0.57**	(0.32, 1.03)	**0.55**	(0.29, 1.06)	**0.80**	(0.38, 1.68)	
RII	**0.29**	(0.14, 0.64)*	**0.47**	(0.19, 1.29)	**0.37**	(0.13, 1.00)	**0.78**	(0.23, 2.64)	0.781
Education level									0.403
Superior BAC	**1.00**		**1.00**		**1.00**		**1.00**		
BAC	**0.63**	(0.32, 1.26)	**0.61**	(0.30, 1.23)	**2.13**	(0.73, 6.18)	**2.09**	(0.70, 6.22)	
Inferior BAC	**0.52**	(0.32, 0.86)*	**0.57**	(0.35, 0.95)*	**0.91**	(0.48, 1.73)	**1.04**	(0.53, 2.05)	
RII	**0.36**	(0.16, 0.79)*	**0.43**	(0.19, 0.98)*	**0.62**	(0.21, 1.81)	**0.80**	(0.26, 2.50)	0.450
Employment									0.786
Employed	**1.00**		**1.00**		**1.00**		**1.00**		
Unemployed	**0.61**	(0.23, 1.62)	**0.60**	(0.23, 1.61)	**0.65**	(0.19, 2.20)	**0.74**	(0.21, 2.68)	
Inactive	**0.68**	(0.46, 1.01)	**0.93**	(0.57, 1.54)	**0.81**	(0.49, 1.36)	**1.30**	(0.65, 2.60)	
Complementary health insurance									0.859
Yes	**1.00**		**1.00**		**1.00**		**1.00**		
No	**0.36**	(0.16, 0.81)*	**0.41**	(0.18, 0.95)*	**0.48**	(0.22, 1.06)	**0.60**	(0.26, 1.42)	
Basic health insurance									0.121
Yes	**0.80**	(0.41, 1.54)*	**0.83**	(0.43, 1.61)	**0.30**	(0.15, 0.58)*	**0.41**	(0.20, 0.85)*	
No	**1.00**		**1.00**		**1.00**		**1.00**		

*p<0.05, **p<0.001.

[†]Adjusted on the covariates: age, region, alcohol consumption, smoking status, close relative with cancer & living in couple

[‡] Calculated using a two way interaction term composed of socioeconomic variable of interest and survey year dummy variable (2010 vs. 2006

Table 4. Association between socio-economic variables and the probability of cervical smear participation in 2005 and 2010: unadjusted[†] and adjusted odds ratios

	Cervical smear 2005 (n=1571)				Cervical smear 2010 (n=1514)				
Socio-economic variable	**Unadjusted OR**	(95% CI)	**Adjusted OR**	(95 % CI)	**Unadjusted OR**	(95% CI)	**Adjusted OR**	(95% CI)	***p*-trend[‡] 2005-2010**
Occupation									0.483
Manager	**1.00**		**1.0**		**1.00**		**1.0**		
Farmer	**0.54**	(0.20, 1.45)	**0.59**	(0.21, 1.65)	**0.79**	(0.19, 3.29)	**0.79**	(0.18, 3.44)	
Self-employed	**0.43**	(0.20, 0.90)*	**0.43**	(0.20, 0.92)*	**0.68**	(0.31, 1.50)	**0.78**	(0.35, 1.75)	
Professional	**0.94**	(0.57, 1.54)	**0.98**	(0.59, 1.61)	**1.43**	(0.89, 2.45)	**1.50**	(0.87, 2.61)	
Employee	**0.62**	(0.40, 0.96)*	**0.66**	(0.42, 1.03)	**0.85**	(0.52, 1.37)	**0.89**	(0.54, 1.46)	
Manual worker	**0.52**	(0.29, 0.92)*	**0.51**	(0.28, 0.92)*	**0.58**	(0.33, 1.01)	**0.67**	(0.37, 1.21)	
Other	**0.75**	(0.38, 1.49)	**0.81**	(0.40, 1.62)	**0.33**	(0.18, 0.60)*	**0.51**	(0.26, 1.00)	
Income									0.364
>€1500	**1.00**		**1.00**		**1.00**		**1.0**		
€1000-1500	**0.46**	(0.32, 0.65)**	**0.54**	(0.37, 0.79)**	**0.66**	(0.43, 1.01)	**0.79**	(0.50, 1.25)	
<€1000	**0.32**	(0.21, 0.49)**	**0.44**	(0.28, 0.70)**	**0.33**	(0.22, 0.49)**	**0.47**	(0.29, 0.76)**	
RII	**0.16**	(0.09, 0.28)**	**0.25**	(0.13, 0.48)**	**0.20**	(0.11, 0.37)**	**0.31**	(0.15, 0.64)*	0.295
Education level									0.828
Superior BAC	**1.00**		**1.00**		**1.00**		**1.0**		
BAC	**0.95**	(0.63, 1.45)	**1.01**	(0.66, 1.55)	**0.97**	(0.59, 1.58)	**0.99**	(0.60, 1.63)	
Inferior BAC	**0.57**	(0.41, 0.77)**	**0.57**	(0.41, 0.80)**	**0.51**	(0.35, 0.73)**	**0.63**	(0.43, 0.94)*	
RII	**0.36**	(0.21, 0.61)**	**0.36**	(0.21, 0.64)**	**0.28**	(0.16, 0.51)**	**0.40**	(0.22, 0.74)*	0.881
Employment									0.392
Employed	**1.00**		**1.00**		**1.00**		**1.0**		
Unemployed	**0.38**	(0.23, 0.61)**	**0.46**	(0.28, 0.75)*	**0.42**	(0.26, 0.67)**	**0.49**	(0.30, 0.81)*	
Inactive	**0.52**	(0.38, 0.71)**	**0.50**	(0.36, 0.71)**	**0.38**	(0.28, 0.52)**	**0.50**	(0.35, 0.73)**	
Complementary health insurance									0.014
Yes	**1.00**		**1.00**		**1.00**		**1.0**		
No	**0.25**	(0.15, 0.40)**	**0.29**	(0.17, 0.49)**	**0.54**	(0.34, 0.88)*	**0.64**	(0.38, 1.08)	
Basic health insurance									0.677
Yes	**0.46**	(0.29, 0.74)*	**0.57**	(0.35, 0.92)*	**0.42**	(0.28, 0.65)**	**0.52**	(0.32, 0.85)*	
No	**1.00**		**1.00**		**1.00**		**1.00**		

*p<0.05, **p<0.001.

[†]Adjusted on the covariates: age, region, alcohol consumption, smoking status, close relative with cancer & living in couple

[‡] Calculated using a two way interaction term composed of socioeconomic variable of interest and survey year dummy variable (2010 vs. 2006

Table 5. Association between socio-economic variables and the probability of FOBT participation in 2005 and 2010: unadjusted[†] and adjusted Odds Ratios

	FOBT 2005 (n=1222)				FOBT 2010 (n=1425)				
Socio-economic variable	**Unadjusted OR**	(95% CI)	**Adjusted OR**	(95% CI)	**Unadjusted OR**	(95% CI)	**Adjusted OR**	95% CI	***p*-trend[‡] 2005-2010**
Occupation									0.372
Manager	**1.00**		**1.0**		**1.00**		**1.0**		
Farmer	**0.57**	(0.29, 1.10)	**0.61**	(0.31, 1.21)	**0.97**	(0.46, 2.05)	**0.72**	(0.32, 1.61)	
Self-employed	**0.78**	(0.46, 1.31)	**0.70**	(0.41, 1.20)	**0.82**	(0.51, 1.31)	**0.80**	(0.48, 1.32)	
Professional	**0.83**	(0.57, 1.23)	**0.90**	(0.60, 1.34)	**0.85**	(0.60, 1.20)	**0.94**	(0.65, 1.37)	
Employee	**0.66**	(0.45, 0.96)*	**0.83**	(0.60, 1.24)	**0.78**	(0.54, 1.12)	**0.99**	(0.66, 1.50)	
Manual worker	**0.67**	(0.44, 1.03)	**0.69**	(0.44, 1.07)	**0.66**	(0.45, 0.96)*	**0.63**	(0.42, 0.96)*	
Other	**0.76**	(0.39, 1.46)	**0.85**	(0.42, 1.73)	**0.58**	(0.36, 0.95)*	**0.71**	(0.41, 1.23)	
Income									0.114
>€1500	**1.00**		**1.00**		**1.00**		**1.00**		
€1000-1500	**0.85**	(0.61, 1.18)	**0.93**	(0.66, 1.31)	**0.94**	(0.67, 1.31)	**1.00**	(0.68, 1.46)	
<€1000	**0.63**	(0.42, 0.94)*	**0.62**	(0.39, 0.97)*	**0.89**	(0.62, 1.29)	**0.99**	(0.64, 1.52)	
RII	**0.54**	(0.31, 0.93)*	**0.70**	(0.38, 1.28)	**0.83**	(0.49, 1.41)	**0.99**	(0.52, 1.86)	0.137
Education level									0.441
Superior BAC	**1.00**		**1.00**		**1.00**		**1.00**		
BAC	**0.79**	(0.50, 1.24)	**0.85**	(0.53, 1.34)	**1.21**	(0.81, 1.83)	**1.25**	(0.80, 1.95)	
Inferior BAC	**0.77**	(0.58, 1.04)	**0.75**	(0.55, 1.02)	**0.99**	(0.74, 1.34)	**0.94**	(0.68, 1.30)	
RII	**0.67**	(0.41, 1.09)	**0.69**	(0.42, 1.14)	**0.90**	(0.56, 1.45)	**0.81**	(0.48, 1.35)	0.466
Employment									0.800
Employed	**1.00**		**1.00**		**1.00**		**1.00**		
Unemployed	**0.86**	(0.40, 1.88)	**1.09**	(0.49, 2.40)	**0.68**	(0.37, 1.27)	**0.86**	(0.45, 1.66)	
Inactive	**1.45**	(1.12, 1.88)*	**1.18**	(0.83, 1.67)	**1.58**	(1.25, 1.99)**	**1.14**	(0.82, 1.58)	
Complementary health insurance									0.485
Yes	**1.00**		**1.00**		**1.00**		**1.00**		
No	**0.50**	(0.25, 0.97)*	**0.53**	(0.26, 1.05)	**0.65**	(0.40, 1.05)	**0.81**	(0.47, 1.38)	
Basic health insurance									0.388
Yes	**0.70**	(0.43, 1.16)	**0.75**	(0.47, 1.22)	**1.03**	(0.69, 1.54)	**1.06**	(0.68, 1.65)	
No	**1.00**		**1.00**		**1.00**		**1.00**		

*p<0.05, **p<0.001.

[†]Adjusted on the covariates: age, region, alcohol consumption, smoking status, close relative with cancer & living in couple

[‡] Calculated using a two way interaction term composed of socioeconomic variable of interest and survey year dummy variable (2010 vs. 2006

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Temporal trend in socio-economic inequalities in the uptake of cancer screening programs in France between 2005 and 2010: Results from the Cancer Barometer Surveys

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Temporal trend in socio-economic inequalities in the uptake of cancer screening programs in France between 2005 and 2010: Results from the Cancer Barometer surveys

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ABSTRACT

Objectives: Cancer screening is a form of secondary prevention for a disease which is now the leading cause of death in France. Various socio-economic-indicators have been identified as potential factors for disparities in breast, cervical and colorectal cancer screening uptake. We aimed to identify the socioeconomic inequalities which persisted in screening uptake for these cancers, and to quantify these disparities over a 5-year-period.

Setting: The Cancer Barometer was a population-based-survey carried out in 2005 and 2010 in France.

Participants: A randomly selected sample of participants aged 15 to 85 years (n=3820 in 2005 and n=3727 in 2010) were interviewed on their participation in breast, cervical and colorectal cancer-screening-programs and their socioeconomic profile.

Primary and secondary outcome measures: For each type of screening-program, we calculated participation rates, odds ratios (OR) and relative inequality indices (RII) for participation, derived from logistic regression of the following socioeconomic variables: income, education, occupation, employment and health insurance. Changes in participation between 2005 and 2010 were then analyzed.

Results: Participation rates for breast and colorectal screening increased significantly among the majority of socioeconomic categories, whereas for cervical cancer screening there were no significant changes between 2005 and 2010. RIIs for income remained significant for cervical smear in 2005 (RII=0.25, 95% CI 0.13-0.48) and in 2010 (RII=0.31, 95% CI 0.15-0.64). RIIs for education in mammography (RII=0.43, 95% CI 0.19-0.98) and cervical smear (RII=0.36, 95% CI 0.21-0.64) were significant in 2005 and remained significant for cervical smear (RII=0.40, 95% CI 0.22-0.74) in 2010.

Conclusions: There was a persistence of socioeconomic inequalities in the uptake of opportunistic cervical cancer screening. Conversely, organized screening-programs for breast and colorectal cancer saw a reduction in relative socioeconomic inequalities, even though the results were not statistically significant. The findings suggest that organized-cancer-screening programs may have the potential to reduce socio-economic disparities in participation.

Key words: cancer screening, breast cancer, cervical cancer, social inequalities, cancer epidemiology

Strengths and limitations of this study

- First study to examine temporal changes in inequalities for cancer screening uptake in France using relative inequality index.
- Benefits from datasets of two identical questionnaires on cancer screening uptake, taken 5 years apart, using two comparable population samples, hence minimizing information bias.
- Evolution in the format of colorectal screening program in terms of technique and age limits may have led to measured differences in uptake between 2005 and 2010.
- Residents of nursing homes and other medical institutions without a personal telephone line were excluded from the survey, limiting the generalizability of the findings.
- Relatively small sample for certain socio-economic strata, reducing therefore the precision of some estimates.

INTRODUCTION

Screening for cancer is an important form of secondary prevention for a disease which is now leading cause of death in France and worldwide [1].The 2008 European report on cancer recommends that health systems focus their resources on cancer prevention and early detection rather than treatment alone, as the global disease burden of cancer threatens to become unsustainable in terms of financial costs, pressure on services, follow-up of patients and delivery of care [2].

To date, many European countries have rolled out screening programs for breast, colorectal and cervical cancer via mammography, faecal occult blood test (FOBT) and cervical smear respectively [3, 4]. However, for these screening programs to have a significant effect on reducing cancer mortality, they require a minimum level of participation among the eligible population; for instance 70% for mammography, and 50% for FOBT [5].

We reviewed several publications from France, United Kingdom (UK), United States of American (USA), Italy, Denmark, Korea and Argentina, which identified variables shown to have a significant effect on cancer screening uptake [6-19]. For breast cancer screening, various different social and economic variables were found to have a positive effect on uptake, including employment, higher occupation class, higher education level, income, private health insurance and car/home ownership. However, no single variable was consistently observed across the studies except for participation in other screening programs [7, 18]. For cervical cancer screening, the variables identified as having a significant positive effect on uptake were more numerous, and notably consistent for income [7, 11, 17], higher education level [10-12, 17, 18], employment[6, 12, 18, 19] and private health insurance [6, 7, 18]. For colorectal screening, income was consistently shown to have a significant positive effect on uptake of screening across the studies [14, 16, 18].

Nevertheless, it remains unclear as to whether the effect of these socio-economic variables on participation rates in screening programs persists over time.

Only one study to date, drawn from the 2006, 2008 and 2010 French Healthcare and Health Insurance surveys, has examined the temporal evolution in breast, cervical and colorectal cancer screening uptake in France [6]. This study conducted among 10 000 participants found that those classified as unskilled workers were more likely to not have undergone cervical cancer screening (OR = 1.64, 95% CI 1.38-1.95) when compared to those with an intermediate profession. The results also showed that women without (OR = 2.05, 95% CI 1.68-2.51) or receiving free complementary health insurance (OR = 1.79, 95% CI 1.36-2.37) were more likely to not have undergone breast cancer screening when compared to those with a private complementary health insurance. In this study, the authors found that inequalities for participation in breast and colorectal cancer screening persisted over the study period from 2006 to 2010 [6].Thus, we believe there is a need to re-examine how these trends may have evolved with respect to expansion in the coverage and awareness of organized cancer screening programs. The third French National Cancer Plan for the 2014-2019 period has identified early detection of cancers as a primary priority [20]. Included within this priority is the reduction of inequalities associated with cancer diagnosis, in the hope of subsequently reducing mortality rates. Any widening or reduction in socio-economic inequalities in the uptake of screening programs that are identified may then be used to direct future policy of the French national cancer control plan, which specifically seeks to address this issue [20]. We aim therefore in the present study to identify the socio-economic inequalities which persist for uptake of breast, cervical and colorectal cancer screening, and to quantify these disparities over a 5-year period in France.

MATERIALS AND METHODS

Study population

We used data, obtained with formal permission, from the Cancer Barometer surveys, two telephone surveys on cancer-related knowledge, attitudes and practices conducted by the French National Institute for Prevention and Health (now part of Santé Publique France). Both surveys were carried out on a representative random sample of the general French population aged over 16 years old for the 2005 survey and aged 15–85 years old for the 2010 survey. A two-stage random sampling design was used. Residents of nursing homes or other medical institutions who did not possess a personal telephone line were not included in the samples. Private households with telephones were included in the sample. The first sampling step was household selection (by phone number). Within each selected household, one French-speaking person aged 15–85 was randomly selected using the "next birthday" method. The study protocol included a formal request to participate, which explained the objectives of the study that was delivered by mail before the first telephone call. Informed consent was obtained at the start of the telephone interview, in accordance with the guidelines of the French Data Protection Authority (CNIL). The interviews were conducted using a computer-assisted telephone interview (CATI) system.

In order to obtain adequate statistical power for measuring associations between variables and changes in participation rates at smaller levels, a sample size of between 3500 and 4000 was deemed appropriate. The 2005 Cancer Barometer sample consisted of 4046 participants aged over 16 years interviewed between April and June 2005 [18].There were 226 individuals with missing observations in the 2005 Cancer Barometer sample, notably for all 3 of the dependent variables, and 7 out of 10 covariates and independent variables. These individuals terminated the survey

prematurely, and were thus removed from the analysis as their data was not contributive, leaving 3820 participants in the sample population. Females (51.5%) responded more often than males (48.5%) and mean age of interviewees was 46.7 years. The 2010 Cancer Barometer sample consisted of 3727 participants aged 15 to 85 interviewed during the first semester of 2010[19]. The mean age was 44.6 years and the majority of participants were also female (52.0%vs. 48.0%). The response rates for the 2005 and 2010 Cancer Barometers were 51.2% and 47.0%, respectively.

Measures

Socio-economic indicators (independent variables) were as follows: education level (inferior, equal to or superior to the baccalauréat [high-school diploma]), employment status (employed, unemployed, and inactive), occupational class (farmer, self-employed, manager, professional, employee, manual worker, other), monthly income (below €1000, €1000-1500, above €1500) and health insurance (private complementary vs. basic insurance coverage). The outcome variables were participation in breast, cervical and colorectal cancer screening programs (dependent variables). For breast cancer screening, participants aged over 40 years were asked if they had undergone mammography within the previous 2 years. For cervical cancer screening, participants aged over 20 years were asked if they had undergone a cervical smear within the previous 3 years. For colorectal cancer screening, participants aged 50-74 years were asked if they had undergone a faecal occult blood test (FOBT) within their lifetime. Covariates included gender, age, smoking status, alcohol consumption, region, living as a couple and having a close relative with cancer. For the calculation of screening participation rates, we added filters to select the target population eligible for each of the 3 different screening programs. Breast screening by mammography (n=1546): female gender and 49<age<75. Cervical screening by cervical smear (n=3085): female gender and 24<age<66. Colorectal screening by FOBT (n=2647): both genders where 49<age<75.

The weighting was based on the data of the 1999 and 2008 Employment Survey of the French population [21], taking into account age, gender, region, education level and number of persons per household [18].This allowed us to effectively calculate age-adjusted standardized rates for screening participation, in addition to later adjusting the regression models for the covariates mentioned.

Statistical analysis

We created a pooled dataset of the two surveys conducted in 2005 and 2010.We calculated age-adjusted screening rates (AAR) for each stratum using the weighting provided by the INPES. The temporal evolution in the participation rate within each stratum between 2005 and 2010 was examined by adding an interaction term for the year of the survey. The disparity within each socio-economic variable was calculated as the absolute difference between the AAR for the highest and lowest group within an ordinal or binary variable for the given year.

Odds ratios (OR), derived from multiple logistic regression of screening participation on each socio-economic variable were used as a measure of participation likelihood for each stratum of the 6 socio-economic variables. The model was adjusted for the covariates: age, gender (colorectal screening only), region, alcohol, smoking, living as a couple and close relative with cancer. For categorical variables, the higher socio-economic position was used as the reference group. The trend for disparities within each socioeconomic variable for each survey was then estimated and compared using a two way interaction term composed of the socioeconomic variable of interest and a survey year dummy variable (2010 vs. 2005), consistent with the methodology of previous studies on the topic[22, 23].

For the ordinal variables of income and education level, we calculated the Relative Inequality Index (RII) as a measure of health inequality as described by Mackenbach and Kunst [24]. Previous studies on health inequalities, including breast cancer screening uptake [4, 9], employed a similar

methodology for examining temporal evolutions within ordered socio-economic strata [23, 25]. The trend in RII for each survey was estimated and compared using a two way interaction term, composed of the socioeconomic variable of interest and a survey year dummy variable (2010 vs. 2005). The RII is a regression-based measure that summarizes the association between two variables. It is computed by ranking income and education values on a scale from the lowest, which is 0, to the highest, which is 1. Each income or education level value covers a range on this scale that is proportional to the number of participants who held that value and is given a new value on the scale corresponding to the cumulative midpoint of its range. The RII resembles relative risk in that it compares the probability of cancer screening uptake at the extremes of income and educational levels, but is estimated using the data on all income and education values and is weighted to account for the distribution of these values. Here the RII was fitted using logistic regression models. An RII of 0.5 for example implies that participants in the most deprived group (those with lower incomes and educations levels) had a 50% lower probability of cancer screening uptake when compared to those in the least deprived group (those with higher incomes and education levels). All statistical analysis was performed using SAS version 9.2.

RESULTS

Table 1 presents the demographic and socio-economic characteristics of the study populations. The overall participation rates among the eligible populations for breast, cervical and colorectal cancer screening are shown in Table 2. Chi-squared tests for the change in participation rates within each socio-economic stratum between 2005 and 2010 are also included. For mammography, participation rates increased significantly ($p<0.05$) among all socio-economic strata, with the exception of farmers, managers, manual workers, unemployed, those with basic health insurance and education level superior to the baccalauréat. For FOBT, participation rates increased significantly among all socio-economic strata between 2005 and 2010, with the exception

of the unemployed or those with an occupation classified as other. For cervical smear participation rates, there were no significant changes in participation rates among any of the socio-economic strata, except for those without complementary health insurance, which increased significantly from 52.5% to 71.0% (p=0.017).

Table 3 shows the results of the logistic regression models for mammography participation on each socio-economic variable separately, adjusted for covariates. In 2005, farmers, self-employed, employees and manual workers showed significantly reduced participation compared to managers, whereas in 2010 the association remained significant only for manual workers. In 2005, those with an education level inferior to the baccalauréat (OR=0.57, 95% CI 0.35-0.95) showed significantly reduced participation compared to those with an education level superior to the baccalauréat, which became non-significant in 2010 (OR=1.04, 95% CI 0.53-2.05).

Table 4 shows the results of the regression model for cervical smear participation for each socio-economic variable. In 2005, significantly reduced participation was observed for self-employed and manual workers, which became non-significant for both in 2010. In 2005, there was significantly reduced participation for those earning <€1000 and €1000-€1500, which remained significant in 2010 for those earning <€1000 (OR=0.47, 95% CI 0.29-0.76). An education level inferior to the baccalauréat showed significantly lower participation in both 2005 and in 2010. In 2005, being unemployed or inactive significantly reduced participation, and remained significant for both in 2010. The odds ratio for cervical smear participation changed significantly (p=0.014) for those without complementary health insurance from 0.29 (95% CI 0.17-0.49) in 2005 to 0.64 (95% CI 0.38-1.08) in 2010. Having only basic health insurance was significantly associated with reduced participation in both periods.

Table 5 shows the logistic regression results for FOBT participation for each socio-economic variable. Concerning occupation, manual workers (OR=0.63, 95% CI 0.42-0.96) showed

significantly reduced participation in 2010. Odds ratios for all other occupations showed reduced participation compared to managers, but at a non-significant level in 2005 and 2010. Those earning <€1000 showed reduced participation in 2005 (OR=0.62, 95% CI 0.32-0.97), which became non-significant in 2010. There were no significant temporal changes in any of the odds ratios for participation in breast or colorectal cancer screening between 2005 and 2010.

The regression of screening participation on income distribution produced RIIs which can be found in Tables 3-5. The results showed significant inequalities for cervical smear (RII=0.25, 95% CI 0.13-0.48) in 2005, but not for mammography (RII=0.47, 95% CI 0.19-1.29) or FOBT (RII= 0.70, 95% CI 0.38-1.28). In 2010, the income-based RII remained significant for cervical smear (RII=0.31, 95% CI 0.15-0.64). For education, mammography (RII=0.43, 95% CI 0.19-0.98) and cervical smear (RII=0.36, 95% CI 0.21-0.64) showed significant inequalities in 2005, whereas the RII for FOBT was non-significant (RII=0.69, 95% CI 0.42-1.14). In 2010, the education-based RII for mammography became non-significant (RII=0.80, 95% CI 0.26-2.50), whereas the RII for cervical smear remained significant (RII=0.40, 95% CI 0.22-0.74). The p-trend for the temporal change in the RIIs (adjusted model), measured by interaction term between 2005 and 2010, was non-significant for all 3 screening programs for income and education level.

DISCUSSION

Our objective was to identify the socio-economic inequalities which persisted in uptake of breast, cervical and colorectal cancer screening, and to quantify the disparities between socioeconomic groups between 2005 and 2010. In absolute terms, a significant increase in participation rates was observed for most socio-economic strata for mammography and for FOBT between 2005 and 2010. Cervical cancer screening, however, saw no significant change in participation rates between 2005 and 2010 (except for those without complementary health insurance). A similar trend was observed when relative inequalities were considered. It should be

noted that some of these inequalities persisted between 2005 and 2010, even though formal statistical tests for trends were generally not significant.

Findings in the context of the literature

We found only one study to date that has examined the temporal evolution in breast, cervical and colorectal cancer screening uptake in France [6]. Our objectives and methods, however, constitute a major difference between our study and the one conducted by Sicsic and Franc. The latter aimed to analyze the obstacles to and levers for breast, cervical, and colorectal cancer screening uptake and their trends over time, whereas the aim of our study was to identify the socio-economic inequalities which persist in the uptake of breast, cervical and colorectal cancer screening, and to quantify these disparities over a 5-year period. Thus, Sicsic and Franc pooled their three samples but did not conduct direct comparisons of associations between indicators of socioeconomic position and uptake of cancer screenings between periods.

The sole point of comparison between the two studies concerns the overall participation in screening programs. Sicsic and Franc found that the screening rate for breast cancer decreased between 2006 and 2010, from 77.6% in 2006 to 74.0% in 2010, but that the difference was not statistically significant. Although our study found an increase in participation rates for breast cancer screening, this was not statistically significant at the 5% level. They also found that colorectal cancer screening uptake increased significantly between 2006 and 2010, from 18.2% in 2006 to 38.9% in 2010. This is consistent with our result showing that colorectal cancer screening uptake significantly increased from 34.0% in 2005 to 51% in 2010. Finally, they found that the screening rate for cervical cancer significantly decreased from 75.3% in 2006 to 71.9% in 2010. For cervical cancer, we found that the rate was stable between 2006 (79.7%) and 2010 (81.4%). In the end, differences in sampling, sample sizes, number of data collection phases, and in desirability bias may explain these differences in participation rates. It should also be noted that the study by Sicsic and

Franc was based on three surveys carried out in 2006, 2008 and 2010, with therefore a two-year interval, whereas the Cancer Barometer survey was conducted at two points in time in 2005 and 2010. Our study confirmed significantly reduced participation for manual workers in breast and colorectal screening and for those with only basic health insurance in breast and cervical screening in 2010. This is consistent with the study by Sicsic and Franc which showed reduced participation in all 3 screening programs for manual workers and those with only basic health insurance. Breast and colorectal cancer screening programs saw the absolute differences in participation rates reduced over time for all socio-economic variables in our study, with the exception of employment and basic health insurance. A study by Kim et al. showed the disparity in mammography participation based on income remained unchanged among the American population, while the disparity based on education decreased from 2000 to 2005[9]. There remains, however, a persistent disparity in participation rates in cervical cancer screening for the majority of socio-economic variables in our study, consistent with the results of De Maio et al. and Sicsic and Franc[6, 17].

The relative inequalities for income and education decreased for breast and colorectal cancer screening in our study, albeit non-significantly. This is somewhat consistent with De Maio et al., which showed a reduction in the RII for breast cancer screening from 2005 to 2009[17]. In the study by Kim et al., the income-based relative inequalities tended to decrease slightly, while those for education remained constant over time[9]. The relative inequalities for cervical cancer screening persisted according to both income and education from 2005 to 2010 in our study, both remaining statistically significant. This is partially consistent with De Maio et al., where the social gradient decreased for income and increased for education between 2005 and 2010[17].

Interpretation of results

Breast and colorectal screening programs are organized at a national level and differences in absolute participation rates and relative inequalities decreased over time for all socio-economic

variables. For both breast and colorectal screening, the odds ratios for manual workers showed reduced participation compared to managers in 2010. Education and occupation are strongly correlated, with manual workers having a higher proportion of participants with an educational level inferior to the baccalauréat (85%) than any other occupational category in 2010. Thus they may have been less aware of the health marketing campaigns for colorectal cancer screening and the recommendation for FOBT, due to the negative effect of lower education on health literacy[14, 26, 27].

Cervical cancer remains without a nationally organized screening program in France. It is the duty of doctors to organize and falls to the individual to pay for opportunistic screening via a cervical smear test. The lack of a nationally organized screening program may impose significant financial, educational and cultural barriers to screening uptake among certain sections of the French population. The financial costs for a consultation and laboratory processing of the screening test may deter those with only basic health insurance, as public reimbursement covers only 70% of the cost[28]. This may account for the persistence of the observed differences in participation rates and large RIIs. Improving the awareness, affordability and access to cervical cancer screening should be prioritized in order to increase participation rates and reduce socio-economic disparities.

Limitations and strengths of the study

Our study used two almost identical datasets to construct a temporal analysis of participation in screening programs in France between 2005 and 2010. The use of relative inequality indices in our study has never before been employed as a measure of the evolution of socio-economic inequalities in cancer screening in the French population. The comparability of the study populations minimized selection bias and the conservation of the questionnaire format minimized information bias.

The study still retains several limitations however. It shares the usual shortcomings of telephone surveys. There is a potential selection bias, as residents of nursing homes or other medical institutions who did not possess a personal telephone line were not included in the samples. The study includes only those who are French-speakers, excluding individuals unable to answer fluently in French. There was no available data on the ethnicity or nationality of participants in the study, which may have been an important source of confounding or effect modification. The exclusion of the above subpopulations, which are likely to be more socio-economically disadvantaged, may have overestimated the screening participation rates in our study.

Our study used two separate sample populations, whose distributions in Table 2 differed significantly for all of the socio-economic indicators and several covariates. The difference in sample distributions may have accounted for the observed differences in screening participation rates. Thus, we cannot rule out that reductions observed in inequalities over time are not simply due to changes in socioeconomic distributions rather than an actual reduction in social inequalities in screening participation.

Changes in screening policies concerning age limits, screening techniques and regional access meant that the 2005 and 2010 Cancer Barometers were not directly comparable for certain programs. The question of screening participation for colorectal cancer was therefore limited to the lifetime use of FOBT. Organized cervical screening was available in 13 regions in 2009, a source of regional variation not present in 2005. Some screening techniques are more memorable for patients, due to the invasiveness of the screening technique or the duration of the screening interval, which may have led to recall bias.

The respective analytical sample sizes in 2005 and 2010 for breast (n=742, n=804), cervical (n=1571, n=1514) and colorectal (n=1222, n=1425) cancer screening may have been too small to capture disparities among socio-economic strata, leading to a low precision of estimates. Missing

observations for each variable accounted for less than 5% of the total population, except for the variable income (16.3% missing in 2005 and 9.3% in 2010). This may have limited the precision of certain estimates, producing participation rates with large standard errors and odds ratios with large confidence intervals. We undertook multiple comparisons in our study. Thus, we cannot exclude that some of the results we have observed are due to chance.

Conclusion

The findings suggest that organized cancer screening programs may have the potential to reduce socio-economic disparities in participation.

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All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf and declare: no support from any organisation for the submitted work; no financial relationships with any organisations that might have an interest in the submitted work in the previous three years; no other relationships or activities that could appear to have influenced the submitted work.

Contributors

HN conceived the study, advised on methodology, reviewed the results of statistical analyses and supervised the final edit of the manuscript. DK reviewed the background literature, run statistical analyses and drafted the manuscript. CE, CL, PA provided advice on methodology and statistical analyses. CL & PA directed the data collection. All authors contributed to the final draft of this manuscript.

Data sharing statement

All data presented in this manuscript came from 2 original datasets of the 2005 and 2010 Cancer Barometer surveys. The original files can be requested by contacting Santé Publique France (formerly INVS and INPES) via Pierre Arvidson (pierre.arwidson@santepubliquefrance.fr) or Christophe Léon (christophe.leon@santepubliquefrance.fr).

Table 1. Standardized† distribution of study populations for 2005 and 2010 Cancer Barometer surveys, p-value for Chi-squared test

Variables	Barometer 2005 (n=3820)		Barometer 2010 (n=3727)		p-value
	n	%	n	%	
Gender					0.660
Male	1854	48,5	1790	48,0	
Female	1966	51,5	1937	52,0	
Region					0.976
Ile-de-France	701	18,4	696	18,7	
West Paris basin	380	10,0	348	9,3	
East Paris basin	305	8,0	290	7,8	
North	257	6,7	238	6,4	
West	508	13,3	504	13,5	
East	334	8,8	321	8,6	
South West	414	10,9	412	11,1	
South East	455	12,0	447	12,0	
Mediterranean	457	12,0	471	12,6	
Occupation					<0.001
Farmer	117	3,1	81	2,2	
Self-employed/craftsman	220	5,8	270	7,2	
Manager/executive	589	15,4	595	16,0	
Professional	773	20,3	914	24,5	
Employee/office worker	970	25,4	829	22,3	
Manual worker	642	16,8	839	22,5	
Other	506	13,3	199	5,3	
Education level					<0.001
Inferior BAC*	1946	52,0	2270	61,2	
BAC	651	17,4	635	17,1	
Superior BAC	1146	30,6	803	21,7	
Monthly Income					<0.001
<€1000	414	13,2	399	12,1	
€1000-1500	663	21,0	499	15,1	
>€1500	2075	65,8	2401	72,8	
Employment					<0.001
Employed	2146	56,2	1851	49,7	
Unemployed	177	4,6	260	7,0	
Inactive	1497	39,2	1615	43,3	
Alcohol consumption					<0.001
Yes	3430	89,8	3195	85,7	
No	389	10,2	532	14,3	
Smoking status					<0.001
Yes	964	25,2	1195	32,1	
No	2856	74,8	2532	67,9	
Close Relative with cancer					0.950
Yes	2366	62,1	2198	62,1	
No	1446	37,9	1339	37,9	
Living in couple					0.071
Yes	2465	64,6	2333	62,6	
No	1351	35,4	1394	37,4	
Complementary Health Insurance					<0.001
Yes	3518	92,6	3210	89,6	
No	282	7,4	375	10,5	
Basic Health Insurance					0.003
Yes	361	10,2	441	12,4	
No	3182	89,8	3109	87,6	

* BAC = Baccalauréat (high-school diploma)

†Weighted by age, gender, region and educational level according to standard population of the 1999 and 2008 Employment Surveys (INSEE)

Table 2. Standardized† participation rates for eligible participants in 3 screening programs, Chi-squared test for 2005-2010, *p*-trend

Socio-economic variable	Mammography			Cervical smear			FOBT		
	participation rate (%) ± SE			participation rate (%) ± SE			participation rate (%) ± SE		
	2005 (n=742)	2010 (n=804)	Chi2 *p*-value	2005 (n=1571)	2010 (n=1514)	Chi2 *p*-value	2005 (n=1222)	2010 (n=1425)	Chi2 *p*-value
Overall	72.1	88.3		79.7	81.4		34.0	51.6	
Occupation									
Farmer	62.49 ±8.24	87.64 ±8.81	0.148	75.61 ±7.28	80.39 ±11.63	0.739	26.97 ±6.69	56.50 ±10.82	0.006
Self-employed	63.70 ±9.46	85.96 ±5.37	0.027	71.02 ±7.00	77.92 ±6.89	0.438	33.47 ±5.61	52.30 ±5.75	0.009
Manager	85.50 ±4.04	91.45 ±2.50	0.262	85.15 ±2.51	83.88 ±3.05	0.740	39.33 ±3.89	57.33 ±3.31	0.0003
Professional	74.87 ±3.74	87.82 ±2.95	0.004	84.31 ±1.95	88.17 ±1.68	0.153	35.04 ±3.21	53.32 ±2.79	<0,0001
Employee	68.76 ±3.00	90.58 ±1.98	<0.0001	78.05 ±1.81	81.52 ±2.06	0.170	29.92 ±2.63	51.07 ±3.54	<0,0001
Manual worker	64.52 ±6.01	76.02 ±5.29	0.161	74.70 ±3.96	75.00 ±4.22	0.956	30.29 ±3.74	46.95 ±4,23	0.001
Other	69.37 ±6.19	83.70 ±5.28	0.097	81.14 ±4.21	62.94 ±6.53	0.010	32.87 ±6.20	43.84 ±6.92	0.204
Education level									
Inferior BAC	67.80 ±2.29	86.26 ±1.79	<0.0001	75.20 ±1.77	76.88 ±1.97	0.484	31.55 ±1.82	51.06 ±2.06	0
BAC	71.86 ±5.71	93.63 ±2.15	0.0003	83.59 ±2.47	86.42 ±2.03	0.385	32.07 ±4.46	56.06 ±3.58	<0,0001
Superior BAC	80.17 ±3.49	87.34 ±2.56	0.153	84.27 ±1.65	86.81 ±1.67	0.318	37.39 ±3.27	51.23 ±2.92	0.002
Difference	*12.37*	*1.08*		*9.07*	*9.93*		*5.84*	*0.17*	
Income									
<€1000	58.45 ±4.48	82.62 ±3.92	0.001	64.78 ±4.01	64.81 ±4.70	1	27.02 ±3.55	49.40 ±4.79	0.0001
€1000-1500	68.62 ±4.19	84.95 ±3.57	0.006	72.43 ±2.96	78.81 ±3.49	0.161	33.29 ±3.35	50.61 ±4.33	0.001
>€1500	76.21 ±2.65	89.57 ±1.59	<0.0001	85.21 ±1.25	84.96 ±1.36	0.885	37.07 ±2.23	52.29 ±1.96	<0,0001
difference	*17.76*	*6.95*		*20.43*	*20.15*		*10.05*	*2.89*	
Complementary health insurance									
Yes	72.09 ±1.84	88.08 ±1.38	<0.0001	81.77 ±1.08	81.83 ±1.29	0.964	33.63 ±1.53	52.31 ± 1.64	<0,0001
No	48.35 ±9.53	78.06 ±7.49	0.013	52.51 ±6.04	71.00 ±5.67	0.017	20.10 ±5.58	41.51 ±7.71	0.011
difference	*23.76*	*10.02*		*29.26*	*10.83*		*13.53*	*10.80*	
Basic health insurance									
Yes	66.12 ±7.38	69.98 ±8.60	0.694	67.20 ±4.70	67.22 ±5.47	1	26.23 ±4.56	52.75 ±6.93	0.0001
No	70.99 ±1.93	88.72 ±1.28	<0.0001	81.52 ±1.12	82.87 ±1.24	0.399	33.83 ±1.60	52.06 ±1.64	<0,0001
difference	*4.87*	*18.74*		*14.32*	*15.65*		*7.60*	*0.69*	
Employment									
Employed	76.23 ±3.07	89.0 ±2.21	0.001	83.75 ±1.21	86.56 ±1.34	0.097	28.37 ±2.42	45.11 ±2.56	<0,0001
Unemployed	66.26 ±9.44	84.1 ±8.73	0.176	66.00 ±5.25	72.88 ±5.23	0.304	25.48 ±6.60	35.91 ± 9.21	0.308
Inactive	68.58 ±2.32	86.79 ±1.75	<0.0001	72.72 ±2.51	71.15 ±2.73	0.665	36.51 ±1.93	56.48 ±2.03	<0,0001

†Weighted by age, gender, region and educational level according to standard population of the 1999 and 2008 Employment Surveys (INSEE)

Table 3. Association between socio-economic variables and the probability of participation in mammography in 2005 and 2010: unadjusted[†] and adjusted odds ratios

	Mammography 2005 (n=742)				Mammography 2010 (n=804)				
Socio-economic variable	**Unadjusted OR**	(95% CI)	**Adjusted OR**	(95% CI)	**Unadjusted OR**	(95% CI)	**Adjusted OR**	(95 % CI)	***p*-trend[‡] 2005-2010**
Occupation									0.521
Manager	**1.00**		**1.0**		**1.00**		**1.0**		
Farmer	**0.28**	(0.10, 0.77)*	**0.33**	(0.12, 0.92)*	**0.66**	(0.08, 5.45)	**0.64**	(0.07, 5.54)	
Self-employed	**0.30**	(0.11, 0.81)*	**0.33**	(0.12, 0.93)*	**0.57**	(0.18, 1.86)	**0.60**	(0.18, 2.00)	
Professional	**0.51**	(0.23, 1.10)	**0.53**	(0.24, 1.18)	**0.67**	(0.26, 1.72)	**0.66**	(0.25, 1.74)	
Employee	**0.37**	(0.18, 0.77)*	**0.39**	(0.19, 0.82)*	**0.90**	(0.36, 2.26)	**1.13**	(0.43, 2.95)	
Manual worker	**0.31**	(0.13, 0.74)*	**0.34**	(0.14, 0.84)*	**0.30**	(0.11, 0.78)*	**0.34**	(0.12, 0.94)*	
Other	**0.38**	(0.16, 0.95)*	**0.45**	(0.17, 1.14)	**0.48**	(0.16, 1.47)	**0.59**	(0.18, 1.95)	
Income									0.775
>€1500	**1.00**		**1.00**		**1.00**		**1.00**		
€1000-€1500	**0.68**	(0.42, 1.11)	**0.83**	(0.50, 1.39)	**0.66**	(0.34, 1.27)	**1.04**	(0.49, 2.20)	
<€1000	**0.44**	(0.26, 0.73)*	**0.57**	(0.32, 1.03)	**0.55**	(0.29, 1.06)	**0.80**	(0.38, 1.68)	
RII	**0.29**	(0.14, 0.64)*	**0.47**	(0.19, 1.29)	**0.37**	(0.13, 1.00)	**0.78**	(0.23, 2.64)	0.781
Education level									0.403
Superior BAC	**1.00**		**1.00**		**1.00**		**1.00**		
BAC	**0.63**	(0.32, 1.26)	**0.61**	(0.30, 1.23)	**2.13**	(0.73, 6.18)	**2.09**	(0.70, 6.22)	
Inferior BAC	**0.52**	(0.32, 0.86)*	**0.57**	(0.35, 0.95)*	**0.91**	(0.48, 1.73)	**1.04**	(0.53, 2.05)	
RII	**0.36**	(0.16, 0.79)*	**0.43**	(0.19, 0.98)*	**0.62**	(0.21, 1.81)	**0.80**	(0.26, 2.50)	0.450
Employment									0.786
Employed	**1.00**		**1.00**		**1.00**		**1.00**		
Unemployed	**0.61**	(0.23, 1.62)	**0.60**	(0.23, 1.61)	**0.65**	(0.19, 2.20)	**0.74**	(0.21, 2.68)	
Inactive	**0.68**	(0.46, 1.01)	**0.93**	(0.57, 1.54)	**0.81**	(0.49, 1.36)	**1.30**	(0.65, 2.60)	
Complementary health insurance									0.859
Yes	**1.00**		**1.00**		**1.00**		**1.00**		
No	**0.36**	(0.16, 0.81)*	**0.41**	(0.18, 0.95)*	**0.48**	(0.22, 1.06)	**0.60**	(0.26, 1.42)	
Basic health insurance									0.121
Yes	**0.80**	(0.41, 1.54)*	**0.83**	(0.43, 1.61)	**0.30**	(0.15, 0.58)*	**0.41**	(0.20, 0.85)*	
No	**1.00**		**1.00**		**1.00**		**1.00**		

*p<0.05, **p<0.001.

[†]Adjusted on the covariates: age, region, alcohol consumption, smoking status, close relative with cancer & living in couple

[‡]Calculated using a two way interaction term composed of socioeconomic variable of interest and survey year dummy variable (2010 vs. 2006).

Table 4. Association between socio-economic variables and the probability of cervical smear participation in 2005 and 2010: unadjusted[†] and adjusted odds ratios

	Cervical smear 2005 (n=1571)				Cervical smear 2010 (n=1514)				
Socio-economic variable	**Unadjusted OR**	(95% CI)	**Adjusted OR**	(95 % CI)	**Unadjusted OR**	(95% CI)	**Adjusted OR**	(95% CI)	***p*-trend[‡] 2005-2010**
Occupation									0.483
Manager	**1.00**		**1.0**		**1.00**		**1.0**		
Farmer	**0.54**	(0.20, 1.45)	**0.59**	(0.21, 1.65)	**0.79**	(0.19, 3.29)	**0.79**	(0.18, 3.44)	
Self-employed	**0.43**	(0.20, 0.90)*	**0.43**	(0.20, 0.92)*	**0.68**	(0.31, 1.50)	**0.78**	(0.35, 1.75)	
Professional	**0.94**	(0.57, 1.54)	**0.98**	(0.59, 1.61)	**1.43**	(0.89, 2.45)	**1.50**	(0.87, 2.61)	
Employee	**0.62**	(0.40, 0.96)*	**0.66**	(0.42, 1.03)	**0.85**	(0.52, 1.37)	**0.89**	(0.54, 1.46)	
Manual worker	**0.52**	(0.29, 0.92)*	**0.51**	(0.28, 0.92)*	**0.58**	(0.33, 1.01)	**0.67**	(0.37, 1.21)	
Other	**0.75**	(0.38, 1.49)	**0.81**	(0.40, 1.62)	**0.33**	(0.18, 0.60)*	**0.51**	(0.26, 1.00)	
Income									0.364
>€1500	**1.00**		**1.00**		**1.00**		**1.0**		
€1000-1500	**0.46**	(0.32, 0.65)**	**0.54**	(0.37, 0.79)**	**0.66**	(0.43, 1.01)	**0.79**	(0.50, 1.25)	
<€1000	**0.32**	(0.21, 0.49)**	**0.44**	(0.28, 0.70)**	**0.33**	(0.22, 0.49)**	**0.47**	(0.29, 0.76)**	
RII	**0.16**	(0.09, 0.28)**	**0.25**	(0.13, 0.48)**	**0.20**	(0.11, 0.37)**	**0.31**	(0.15, 0.64)*	0.295
Education level									0.828
Superior BAC	**1.00**		**1.00**		**1.00**		**1.0**		
BAC	**0.95**	(0.63, 1.45)	**1.01**	(0.66, 1.55)	**0.97**	(0.59, 1.58)	**0.99**	(0.60, 1.63)	
Inferior BAC	**0.57**	(0.41, 0.77)**	**0.57**	(0.41, 0.80)**	**0.51**	(0.35, 0.73)**	**0.63**	(0.43, 0.94)*	
RII	**0.36**	(0.21, 0.61)**	**0.36**	(0.21, 0.64)**	**0.28**	(0.16, 0.51)**	**0.40**	(0.22, 0.74)*	0.881
Employment									0.392
Employed	**1.00**		**1.00**		**1.00**		**1.0**		
Unemployed	**0.38**	(0.23, 0.61)**	**0.46**	(0.28, 0.75)*	**0.42**	(0.26, 0.67)**	**0.49**	(0.30, 0.81)*	
Inactive	**0.52**	(0.38, 0.71)**	**0.50**	(0.36, 0.71)**	**0.38**	(0.28, 0.52)**	**0.50**	(0.35, 0.73)**	
Complementary health insurance									0.014
Yes	**1.00**		**1.00**		**1.00**		**1.0**		
No	**0.25**	(0.15, 0.40)**	**0.29**	(0.17, 0.49)**	**0.54**	(0.34, 0.88)*	**0.64**	(0.38, 1.08)	
Basic health insurance									0.677
Yes	**0.46**	(0.29, 0.74)*	**0.57**	(0.35, 0.92)*	**0.42**	(0.28, 0.65)**	**0.52**	(0.32, 0.85)*	
No	**1.00**		**1.00**		**1.00**		**1.00**		

*p<0.05, **p<0.001.

[†]Adjusted on the covariates: age, region, alcohol consumption, smoking status, close relative with cancer & living in couple

[‡] Calculated using a two way interaction term composed of socioeconomic variable of interest and survey year dummy variable (2010 vs. 2006

Table 5. Association between socio-economic variables and the probability of FOBT participation in 2005 and 2010: unadjusted[†] and adjusted Odds Ratios

	FOBT 2005 (n=1222)				FOBT 2010 (n=1425)				
Socio-economic variable	**Unadjusted OR**	(95% CI)	**Adjusted OR**	(95% CI)	**Unadjusted OR**	(95% CI)	**Adjusted OR**	95% CI	***p*-trend[‡] 2005-2010**
Occupation									0.372
Manager	**1.00**		**1.0**		**1.00**		**1.0**		
Farmer	**0.57**	(0.29, 1.10)	**0.61**	(0.31, 1.21)	**0.97**	(0.46, 2.05)	**0.72**	(0.32, 1.61)	
Self-employed	**0.78**	(0.46, 1.31)	**0.70**	(0.41, 1.20)	**0.82**	(0.51, 1.31)	**0.80**	(0.48, 1.32)	
Professional	**0.83**	(0.57, 1.23)	**0.90**	(0.60, 1.34)	**0.85**	(0.60, 1.20)	**0.94**	(0.65, 1.37)	
Employee	**0.66**	(0.45, 0.96)*	**0.83**	(0.60, 1.24)	**0.78**	(0.54, 1.12)	**0.99**	(0.66, 1.50)	
Manual worker	**0.67**	(0.44, 1.03)	**0.69**	(0.44, 1.07)	**0.66**	(0.45, 0.96)*	**0.63**	(0.42, 0.96)*	
Other	**0.76**	(0.39, 1.46)	**0.85**	(0.42, 1.73)	**0.58**	(0.36, 0.95)*	**0.71**	(0.41, 1.23)	
Income									0.114
>€1500	**1.00**		**1.00**		**1.00**		**1.00**		
€1000-1500	**0.85**	(0.61, 1.18)	**0.93**	(0.66, 1.31)	**0.94**	(0.67, 1.31)	**1.00**	(0.68, 1.46)	
<€1000	**0.63**	(0.42, 0.94)*	**0.62**	(0.39, 0.97)*	**0.89**	(0.62, 1.29)	**0.99**	(0.64, 1.52)	
RII	**0.54**	(0.31, 0.93)*	**0.70**	(0.38, 1.28)	**0.83**	(0.49, 1.41)	**0.99**	(0.52, 1.86)	0.137
Education level									0.441
Superior BAC	**1.00**		**1.00**		**1.00**		**1.00**		
BAC	**0.79**	(0.50, 1.24)	**0.85**	(0.53, 1.34)	**1.21**	(0.81, 1.83)	**1.25**	(0.80, 1.95)	
Inferior BAC	**0.77**	(0.58, 1.04)	**0.75**	(0.55, 1.02)	**0.99**	(0.74, 1.34)	**0.94**	(0.68, 1.30)	
RII	**0.67**	(0.41, 1.09)	**0.69**	(0.42, 1.14)	**0.90**	(0.56, 1.45)	**0.81**	(0.48, 1.35)	0.466
Employment									0.800
Employed	**1.00**		**1.00**		**1.00**		**1.00**		
Unemployed	**0.86**	(0.40, 1.88)	**1.09**	(0.49, 2.40)	**0.68**	(0.37, 1.27)	**0.86**	(0.45, 1.66)	
Inactive	**1.45**	(1.12, 1.88)*	**1.18**	(0.83, 1.67)	**1.58**	(1.25, 1.99)**	**1.14**	(0.82, 1.58)	
Complementary health insurance									0.485
Yes	**1.00**		**1.00**		**1.00**		**1.00**		
No	**0.50**	(0.25, 0.97)*	**0.53**	(0.26, 1.05)	**0.65**	(0.40, 1.05)	**0.81**	(0.47, 1.38)	
Basic health insurance									0.388
Yes	**0.70**	(0.43, 1.16)	**0.75**	(0.47, 1.22)	**1.03**	(0.69, 1.54)	**1.06**	(0.68, 1.65)	
No	**1.00**		**1.00**		**1.00**		**1.00**		

*p<0.05, **p<0.001.

[†]Adjusted on the covariates: age, region, alcohol consumption, smoking status, close relative with cancer & living in couple

[‡] Calculated using a two way interaction term composed of socioeconomic variable of interest and survey year dummy variable (2010 vs. 2006

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found**: Included, please see page 1 and 2.**
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported **Included, please see 5 and 6**
Objectives	3	State specific objectives, including any prespecified hypotheses**. Included please see page 6, last sentence.**
Methods		
Study design	4	Present key elements of study design early in the paper. **Included, please see page 7, study population section, first paragraph.**
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection. **Included, please see page 7, study population section, second paragraph.**
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants**. Included, please see page 7, study population section, first paragraph.**
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable**. Included, please see page 8, Measures section.**
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group. **Included, please see page 8, Measures section.**
Bias	9	Describe any efforts to address potential sources of bias. **Included, please see page 7, second sentence, study population section, and page 8, last paragraph, Measures section.**
Study size	10	Explain how the study size was arrived at**. Included, please page 7, second paragraph, study population section.**
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why**. Included, please page 8, Measures sections.**
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding **Included, please page Statistical Analysis section pages 9-10**
		(*b*) Describe any methods used to examine subgroups and interactions **Included,**

	please statistical analysis section, second and third paragraphs.
(*c*) Explain how missing data were addressed. **Included, please see page 7, study population section, second paragraph.**	
(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy**. Included, please see page 8, Measures section, last paragraph.**	
(*e*) Describe any sensitivity analyses. **N/A.**	

Continued on next page

Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed **YES**
		(b) Give reasons for non-participation at each stage **YES**
		(c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders **YES**
		(b) Indicate number of participants with missing data for each variable of interest **YES**
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures **YES**
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included **YES**
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period **YES**
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results	18	Summarise key results with reference to study objectives **YES**
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias **YES**
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence **YES**
Generalisability	21	Discuss the generalisability (external validity) of the study results **YES**
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based **YES**

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.