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Abstract

This paper examines the effectiveness of France's organized cancer screening programs by leveraging age-based eligibility thresholds to identify causal effects on screening uptake. Using 2019 telephone survey data matched with medico-administrative records from 1,411 women insured by MGEN, we employ a fuzzy regression discontinuity design to estimate Local Average Treatment Effects at program entry and exit ages. Our results reveal dramatic discontinuities in screening behavior: entering mammography screening eligibility at age 50 increases uptake probability by 59 percentage points (pp) ($p < 0.001$), while exiting eligibility at age 75 decreases uptake by 39pp ($p = 0.014$). For cervical screening, we find no significant discontinuity at the entry age of 25, but observe a substantial decrease at the exit age of 66 (-30pp, $p = 0.080$). Importantly, these effects vary significantly according to individual risk attitudes measured using the DOSPERT scale. *risk-taking* women drive the positive entry effects for mammography screening (+74pp, $p < 0.001$ versus non-significant effects for *risk-averse* women), while *risk-averse* women are particularly susceptible to negative exit effects (-31pp, $p = 0.035$). These findings suggest that age-targeted screening policies create temporary behavioral changes rather than sustained health habits, with heterogeneous impacts based on individual risk preferences. Our results have important implications for designing more personalized public health interventions that account for individual psychological characteristics.

Keywords

Cancer screening test uptake; fuzzy regression discontinuity; attitude towards risk

JEL Classification Codes

C26; I12; I14; I18

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1 Introduction

Breast and cervical cancers impose a devastating burden on women's health globally, accounting for 11.7% and 3.1% of all new cancer cases respectively (Sung et al., 2021). Despite advances in treatment, breast cancer remains the leading cause of cancer deaths among women (1 in 6 fatalities), with cervical cancer ranking fourth (1 in 13 deaths). To diagnose cancer cases as early as possible and identify them at early stages, western countries have implemented age-targeted screening programs with remarkably consistent protocols (Ren et al., 2022; Schünemann et al., 2020; Bouvard et al., 2021; Jansen et al., 2020). Ebell et al.'s analysis of 21 high-income countries shows biennial mammograms for women aged 50-69 (Ebell et al., 2018), though some countries begin earlier (Austria, Sweden) or extend later (France, Netherlands, Sweden to age 74). Cervical cancer screening varies more substantially in methodology and target populations (typically ages 30-59), though many EU countries including France begin at age 25 and extend to age 65.

The EU established ambitious targets of 70% breast cancer and 80% cervical cancer screening participation (Boulat et al., 2019), yet reality falls drastically short. Across 27 EU countries (2019-2020), breast cancer screening ranged from 9% (Romania) to 95% (Sweden), while cervical screening varied from 22% (Malta) to 80% (Sweden) (Dupays and Le Guen, 2022). France achieved only 49% and 58% participation respectively, though breast cancer figures likely underestimate actual participation by 10 percentage points due to opportunistic screening (European Union, 2022). Screening adherence is shaped by supply-side factors (healthcare provider accessibility, program organization) and demand-side factors (socioeconomic status, health characteristics, cultural factors). Research shows limited evidence linking specialist physician density to screening uptake (Pornet et al., 2010), though shortages disproportionately affect rural and low-income women (Coughlin et al., 2008). Demand-side determinants include socioeconomic status (Jolidon, 2022), individual health characteristics (Murphy et al., 2021), and cultural factors influencing health behaviors (Murphy et al., 2021; Le Clainche et al., 2024).

This paper examines the effectiveness of France's dual screening approach: nationally organized campaigns offering free biennial mammograms and recommendations for triennial Pap smears without specific public financial coverage. Both programs were designed to stimulate uptake (Buchmueller and Goldzahl, 2018), but participation continues to follow a social gradient potentially exacerbated by inequitable healthcare provision (Ouanhnon et al., 2022). Since this gradient does not depend exclusively on financial motives, suboptimal rates demand scrutiny of program effectiveness. Mammography decisions appear insensitive to invitation letter information (Goldzahl et al., 2018), while risk preferences contribute more than socioeconomic factors to screening heterogeneity, with screening negatively correlated with risk aversion (Goldzahl, 2017). More precisely, this paper quantifies how age eligibility boundaries impact women's screening behavior using 2019 telephone survey data matched with medico-administrative records from randomly selected MGEN (*Mutuelle Générale de l'Education Nationale*) insurees. We measure effects of both entering target ages (50 for mammography, 25 for cervical screening) and, originally, exiting them (75 for mammography, 66 for cervical screening) on screening probability using fuzzy regression discontinuity design and document heterogeneity using individual risk attitude measures. Controlling for supply- and demand-side factors, we reveal how age thresholds dramatically influence participation. Through risk attitudes, entry into (exit from) targeted age periods has major positive (negative) impacts on women who take the most (least) risk.

2 Institutional framework, data and model

2.1 French health insurance and cancer screening test schemes

In France, the national health insurance (NHI), known as *Sécurité sociale*, establishes a *basket of care* eligible for reimbursement. On average, 79.5% of this care is reimbursed to any French citizen (Didier and Lefebvre, 2024). The remaining costs, along with care not covered by the NHI, can be reimbursed through voluntary complementary health insurance (CHI) contracts, which are held by 95% of those covered by the NHI (Barlet et al., 2020).

Since 2004, asymptomatic women aged 50 to 74 with no particular identified risk factors are invited by the NHI every two years to undergo a mammogram paid for with a voucher at any accredited radiology centre (Lefeuvre et al., 2019). Outside this age group, women can undergo opportunistic tests, the cost of which (€66.42 in 2025) minus a deductible of €2 is reimbursed at 70% by the NHI, with possible top-up coverage from the CHI. Some radiologists may charge additional fees that are not reimbursed. If mammograms are part of the follow-up treatment or monitoring of an already diagnosed breast cancer, the cost is fully covered under the exemption from co-payment linked to recognition of the disease.

At the time of the survey, diagnostic tests for cervical cancer were recommended every three years from age 25 to 65 using cytological tests (Pap smears). Unlike mammography, there was no organised national screening campaign at this time. Women were encouraged to undergo the procedure at their gynaecologist's office, GP's office, midwife's clinic, health centre, or family planning centre. Women had to pay in advance for the consultation with a doctor (€30 for a GP, €40 for a gynaecologist in 2025, excluding additional fees) or a midwife, but not for the test at a health centre or family planning clinic. The test (€12.46) and the biological examination (€15.40) are reimbursed by the social security system at a rate of 70%, with top-up coverage available through supplementary insurance. Since then, an organised screening programme has been established that incorporates Pap smears from ages 25 to 29 and human papillomavirus high-risk testing from ages 30 to 65, with the same financing schemes as mammograms (Hamers et al., 2022).

To some extent, these two fundamentally distinct approaches (systematic public funding for mammograms between ages 50 and 74, versus no such funding for Pap smears at the time of the study) create a natural experiment. Women having to pay for Pap smears serve as a control group, making it possible to assess the impact of free access to breast cancer screening tests.

2.2 Data

2.2.1 Sample

The survey sample consisted of adult policyholders covered by a voluntary CHI contract offered by MGEN, a French health insurer that ranks as the second largest complementary insurer in France. The contract is open to all eligible individuals. Participants were randomly selected to participate in a telephone survey conducted between January and June 2019. Of 4,580 randomly selected individuals, 2,757 completed the telephone survey (60.2% participation rate). The final sample comprised 1,411 female respondents with complete data for all variables of interest in this study (additional details about the sample in Sevilla-Dedieu et al. (2025)).

Participants had a mean age of 48.9 years and an average of 1.2 children. Nearly half lived as part of a couple (49.6%), the majority held at least a baccalaureate diploma (82.8%), most had medium-level CHI coverage (57.6%), and a quarter reported financial difficulties (25.0%). Compared to French national statistics, women in the general population are considerably less qualified than our respondents (only 48.6% hold at least a bachelor's degree). This educational disparity may influence overall screening participation rates, since research consistently demonstrates that individuals with higher education levels are more likely to participate in cancer screening, whether through opportunistic screening tests (Willems and Bracke, 2018) or organized campaigns (Damiani et al., 2015). A woman was considered part of the target population for a given screening if she fell within the target age range as defined by current recommendations: 50–74 years for mammograms and 25–65 years for Pap smears.

2.2.2 Questionnaire

The questionnaire documents socio-demographics, CHI contracts, health, healthcare avoidance, future attitudes, and risk attitudes measured using the 30-item DOSPERT scale across five dimensions (Blais and Weber, 2006). Survey data were matched with MGEN's medico-administrative records and supplemented with local radiologist and gynecologist density data (for a comprehensive presentation of the questionnaire, see Ristori (2023)).

2.2.3 Variables

Outcome variables are dichotomous (yes/no): "*mammography within the last 2 years*" and "*Pap smear within the last 3 years*".

Covariates include marital status, number of children, level of education, co-payment exemption, financial difficulties, CHI level, future attitudes (measured on a 0-10 scale ranging from "*living day to day*" to "*worried about future*"), and DOSPERT score measuring risk attitudes across five dimensions: ethical, social, health/safety, financial, and recreational activities. We also control for local radiologist and gynecologist density at the municipal level to reflect screening accessibility, as screening necessarily requires radiologists for mammograms and gynecologists for Pap smear tests. Although midwives and general practitioners can also perform Pap smears, they account for only about 15% of tests carried out in France.

2.3 Model

2.3.1 A fuzzy regression discontinuity design

Biennial mammograms and triennial Pap smears constitute the recommended screening frequencies for women aged 50 to 74 and 25 to 65, respectively. However, these recommendations do not apply universally to all women without exception. Women may need to undergo these tests outside the target age group, for example as part of treatment for an existing cancerous condition, to monitor breast abnormalities, to assess family history risk, or to detect predisposing genes. Conversely, women within the target age group may not be current with these screening tests due to barriers in accessing healthcare providers or personal reluctance to participate. The *jump* (or *drop*) in the *treatment* rate upon entering (or exiting) the age period targeted by public health authorities cannot be assumed to range from 0 to 100% (or from 100 to 0%). In this context, the *treatment* effect cannot be captured using a *sharp* regression discontinuity design, but rather requires a *fuzzy* regression discontinuity approach, which assesses the treatment effects among *compliers*, as denominated by Angrist et al. (1996), to the public health recommendation. This approach accounts for the fact that not all eligible women take the test and some non-eligible women do so anyway. To control for variables that may explain why some women receive the *wrong* treatment—that is, undergoing screening while outside the target age range or failing to screen while within it—covariates are introduced into the regression model. These covariates are expected to reduce unexplained variation and improve estimator precision.

2.3.2 Estimation strategy

As a result, we estimate two Local Average Treatment Effects (LATE), $\underline{\text{LATE}}$ and $\overline{\text{LATE}}$, at the cutoffs $\underline{c}$ and $\overline{c}$ corresponding, respectively, to the lower and upper thresholds of the age period targeted by the two programs:

$$\underline{\text{LATE}} = \frac{\lim_{x \to \underline{c}^+} \mathbb{E}[Y_i \mid X_i = x, Z_i] - \lim_{x \to \underline{c}^-} \mathbb{E}[Y_i \mid X_i = x, Z_i]}{\lim_{x \to \underline{c}^+} \mathbb{E}[D_i \mid X_i = x, Z_i] - \lim_{x \to \underline{c}^-} \mathbb{E}[D_i \mid X_i = x, Z_i]}$$
$$\overline{\text{LATE}} = \frac{\lim_{x \to \overline{c}^+} \mathbb{E}[Y_i \mid X_i = x, Z_i] - \lim_{x \to \overline{c}^-} \mathbb{E}[Y_i \mid X_i = x, Z_i]}{\lim_{x \to \overline{c}^+} \mathbb{E}[D_i \mid X_i = x, Z_i] - \lim_{x \to \overline{c}^-} \mathbb{E}[D_i \mid X_i = x, Z_i]}$$

where Y_i refers to timely screening test uptake by woman i, X_i is the running variable (age) of woman i, Z_i is a vector that gives the values of covariates for woman i, and D_i is the *treatment* assignment, which is not deterministic: $\mathbb{P}(D_i = 1 \mid X_i)$ jumps (respectively drops) at $X_i = \underline{c}$ (respectively $X_i = \overline{c}$), but $D_i \neq \mathbb{1}(X_i \geq \underline{c})$ (respectively $D_i \neq \mathbb{1}(X_i \geq \overline{c})$).

The two Local Average Treatment Effects $\underline{\text{LATE}}$ and $\overline{\text{LATE}}$ are identified using Two-Stage Least Squares (2SLS). $\underline{\text{LATE}}$ is estimated with $\beta_{\underline{\text{LATE}}}$, which assesses how entering the age period impacts screening test uptake Y_i using instrumented D_i:

$$D_i = \pi_{10} + \pi_{11} \cdot \mathbb{1}(X_i \geq \underline{c}) + f_1(X_i - \underline{c}) + Z_i\delta_1 + \nu_{1i} \tag{1}$$
$$Y_i = \alpha_2 + \beta_{\underline{\text{LATE}}} \cdot \hat{D}_i + f_2(X_i - \underline{c}) + Z_i\gamma_2 + \varepsilon_{2i} \tag{2}$$

where $\mathbb{1}(X_i \geq \underline{c})$ serves as an instrument for D_i, and $f_1(\cdot)$ and $f_2(\cdot)$ are polynomial controls.

Similarly, $\overline{\text{LATE}}$ is estimated with $\beta_{\overline{\text{LATE}}}$, which assesses how exiting the age period impacts screening test uptake Y_i:

$$D_i = \pi_{30} + \pi_{31} \cdot \mathbb{1}(X_i \geq \overline{c}) + f_3(X_i - \overline{c}) + Z_i\delta_3 + \nu_{3i} \tag{3}$$
$$Y_i = \alpha_4 + \beta_{\overline{\text{LATE}}} \cdot \hat{D}_i + f_4(X_i - \overline{c}) + Z_i\gamma_4 + \varepsilon_{4i} \tag{4}$$

where $\mathbb{1}(X_i \geq \overline{c})$ serves as an instrument for D_i, and $f_3(\cdot)$ and $f_4(\cdot)$ are polynomial controls.

3 Results

3.1 Cancer screening tests uptake: summary statistics

Among surveyed women, 37.5% (95% CI: 34.9%-40.0%) were up to date with breast cancer screening, revealing a substantial gap between women within the target age range (60.7%, 95% CI: 56.3%-65.1%) and those outside it (25.3%, 95% CI: 22.4%-28.1%). Similarly, 55.7% (95% CI: 53.0%-58.3%) had undergone a Pap smear test within the past three years, with uptake rates of 63.5% (95% CI: 60.6%-66.5%) among women in the target age range and 30.5% (95% CI: 25.3%-35.7%) among those outside it (Table 1). As expected, the proportion of women up to date with their tests increases as they approach the recommended screening period (biennial mammogram from 50 to 74 years; triennial Pap smears from 25 to 65 years) and decreases as they move beyond it, reaching maximum compliance within the target age ranges and minimum compliance outside them (Figure 1).

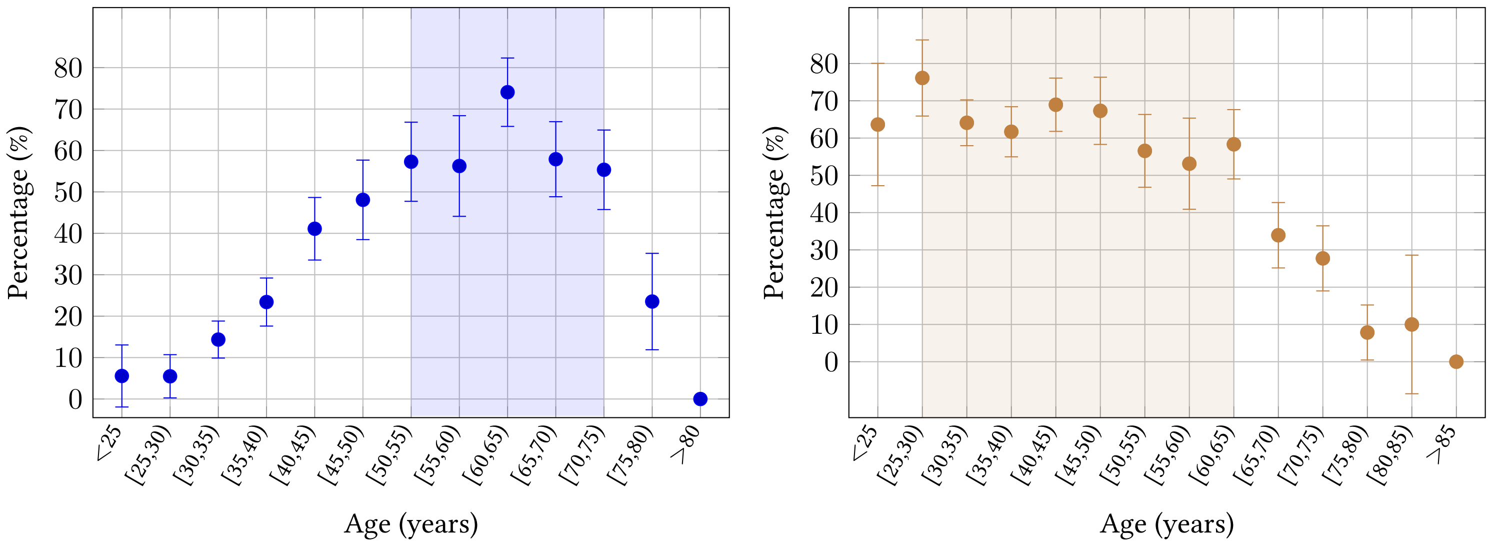
When dichotomizing the sample using the median DOSPERT score (72), breast cancer screening uptake was substantially higher among women with scores at or below the median (henceforth termed as the half most *risk-averse*) compared to those with higher scores (termed as the half most *risk-takers*): 47.3% versus 27.3% ($p < .001$). This difference could not be attributed solely to varying proportions of women in the target age range between subgroups (40.4% among *risk-averse* versus 28.2% among *risk-takers*), as the pattern persisted both within the target age range (67.7% versus 50.3%, $p < .001$) and outside it (33.4% versus 18.3%, $p < .001$).

Table 1. Survey respondents up to date with cancer screening tests (%)

	Mammograms			
	All $n = 1,375$	*Risk-averse* **(1)** $n = 698$	*Risk-taker* **(2)** $n = 677$	p-value **(3)**
In target **(4)**	60.7%	67.7%	50.3%	$< .001$
Out of target **(4)**	25.3%	33.4%	18.3%	$< .001$
All	37.5%	47.3%	27.3%	$< .001$
	Pap smears			
	All $n = 1,349$	*Risk-averse* **(1)** $n = 691$	*Risk-taker* **(2)** $n = 658$	p-value **(3)**
In target **(5)**	63.5%	70.6%	57.4%	$< .001$
Out of target **(5)**	30.5%	27.6%	36.4%	.120
All	55.7%	57.3%	54.0%	.215

Interpretation: 60.7% of survey respondents within the target group for breast cancer screening recommendations were up to date with mammograms
Notes: **(1)** Respondents with DOSPERT score less than or equal to the median score (72) of all survey respondents **(2)** Respondents with DOSPERT score higher than the median score (72) of all survey respondents **(3)** p-value associated with the two-tailed test of equality of proportions **(4)** In target: women aged 50-74; out of target: women aged 49 at most or 75 at least **(5)** In target: women aged 25-65; out of target: women aged 24 at most or 66 at least

Figure 1. Proportion (% point estimates and 95% CI) of women up to date with screening test (left: mammogram, right: Pap smear), by age



Interpretation: About 73% of respondents aged 60-64 were up to date with their mammograms.

In contrast, risk attitude as measured by the DOSPERT score did not similarly predict Pap smear screening behavior. Overall uptake rates between *risk-averse* and *risk-taking* respondents showed no significant difference (57.3% versus 54.0%, $p = .215$). However, this pattern varied by age group: among women outside the target age range, no significant difference was observed (27.6% versus 36.4%, $p = .120$), while among women within the target age range, *risk-averse* women demonstrated significantly higher uptake rates than their *risk-taking* counterparts (70.6% versus 57.4%, $p < .001$).

Overall, these descriptive statistics provide evidence of higher screening compliance among women within rather than outside the age ranges targeted by public health recommendations, and among *risk-averse* rather than *risk-taking* women. However, several questions remain to be addressed: whether these recommendations significantly encourage timely screening uptake at the expected frequencies among the target population, whether there are identifiable discontinuities in screening behavior at the boundaries of eligible age periods that create threshold effects, and whether these impacts affect all women uniformly or vary according to individual risk profiles identified in the survey.

3.2 Estimated regression discontinuities caused by eligibility age periods

Controlling for covariate contributions, including individual psychological inclinations of interest (attitudes toward future and risk), we estimated consistent and opposing *treatment* effects of entering and exiting the age periods targeted by public health initiatives for timely completion of both mammograms and Pap smears (Figure 2). The best fit to the observed data was achieved using linear adjustment, with the exception of the lower cutoff for mammogram uptake, which required a second-order polynomial specification.

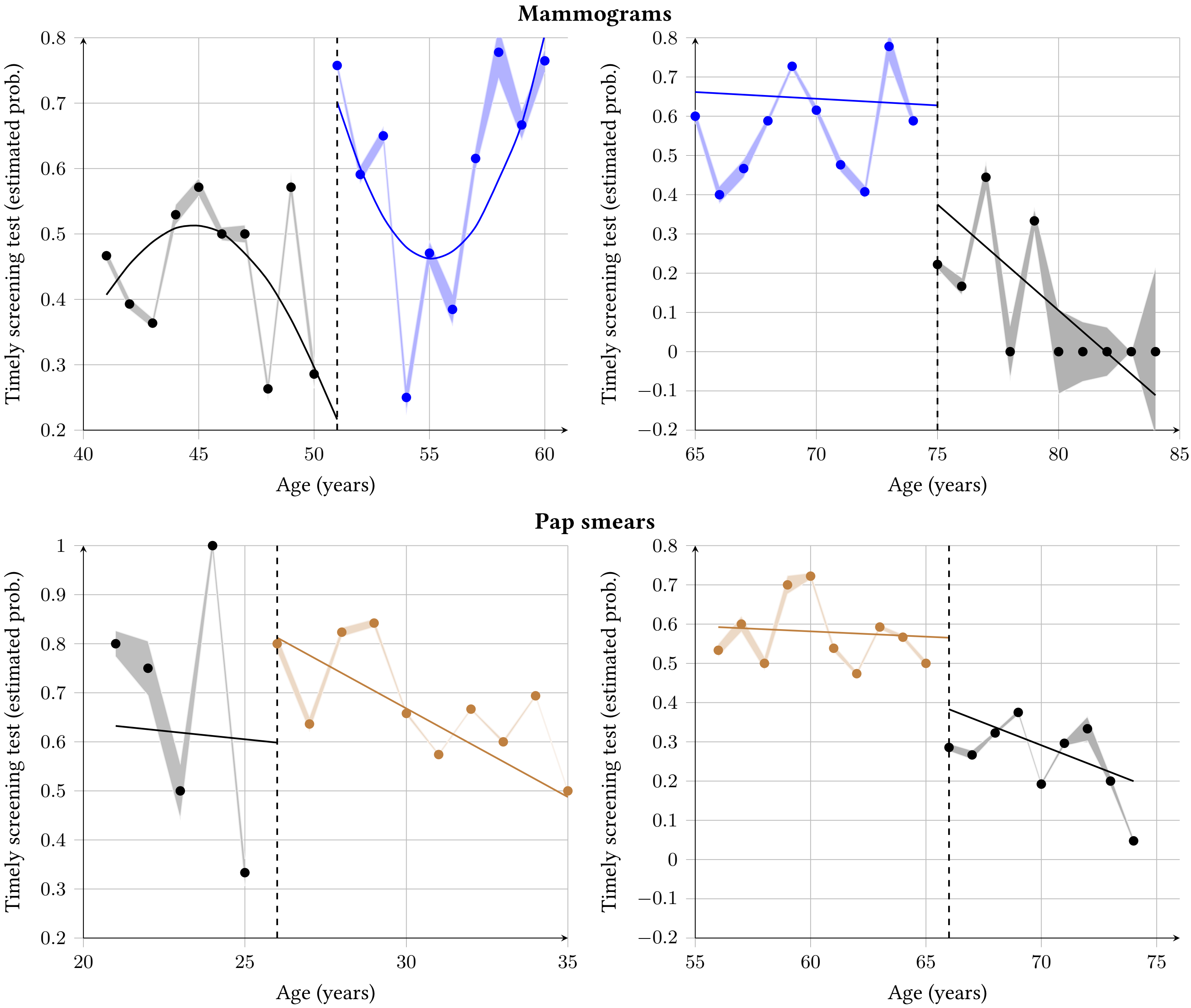
Compared to counterparts aged less than 50, respondents aged 50 and older demonstrated a probability of being up to date with breast cancer screening that was increased by 58.89 percentage points (pp) ($p < .001$) (Table 2). Among *risk-averse* respondents, no significant discontinuity was found locally around age 50; conversely, *risk-taking* respondents aged 50 and older were significantly more likely (+73.82pp, $p < .001$) to be current with their screening compared to younger counterparts. At the upper end of the age range targeted by public health authorities, the probability of being up to date with breast cancer screening dropped by 39.09pp from age 75 ($p = .014$); this decline was significantly pronounced among the more *risk-averse* respondents (-30.68pp, $p = .035$).

The discontinuities in Pap smear uptake shown in Figure 2 were not statistically significant except at the upper threshold at age 65 (-30.08pp, $p = .080$). Unlike mammogram uptake, we were unable to identify any heterogeneous discontinuity effects using the risk attitude measure captured by the DOSPERT score.

The estimated effects and their significance levels proved remarkably stable across various bandwidths (up to ten years) around the lower and upper thresholds (Figure 3 in Appendix), showing positive (negative) and globally (almost) statistically significant effects at the lower (upper) cutoff for mammograms, and globally non-significant effects for Pap smears, except for marginally negative effects at the upper cutoff.

In Table 2, respondents who were the most *risk-taking* (most *risk-averse*) according to the DOSPERT score exhibited a strong positive discontinuity of +73.82pp (negative discontinuity of -30.68pp) in mammogram uptake at age 51 (age 75). Refining the measurement of respondents' risk attitudes using each of the five DOSPERT scale domains confirmed the upward discontinuity in timely mammogram completion after age 50 across all DOSPERT domain-specific dimensions, stronger for the half most *risk-taking* respondents than for the most *risk-averse* ones (the local *treatment* effect ranging from 59pp for finance to 81pp for recreation) (Table 3 in Appendix). Regarding the upper cutoff, no domain-specific dimension yielded results inconsistent with those presented for the half most *risk-averse* respondents according to the global DOSPERT score: exiting the eligible age period did not cause any statistically significant discontinuity, regardless of the domain-specific dimension.

Figure 2. Fuzzy RD plot of treatment effect at lower (left) and upper (right) eligibility cutoffs (robust point estimates, 95% CI and linear/polynomial fit)



Note: Predicted probability to undertake screening tests from heteroskedasticity-corrected and robust estimation with covariates vector Z_i including: number of children, diploma, chronic condition, CHI coverage, financial difficulty, time preference, attitude toward risk (global DOSPERT score), local gynecologist and radiologist densities. Covariates discontinuous at the cutoff excluded: CHI coverage and time preference (lower cutoff for mammograms), financial difficulty (upper cutoff for mammograms), attitude toward risk (lower and upper cutoffs for Pap smears). MSE-based optimal bandwidth (BW).

Among the most *risk-averse* respondents, domain-specific dimensions generally confirmed the results obtained from the global DOSPERT score concerning the decline in timely mammogram uptake when exiting the eligible age period (ranging from -28pp for recreational risk to

Table 2. $\underline{\text{LATE}}$ and $\overline{\text{LATE}}$ estimates for timely screening test uptake

	Mammograms (1)								
	All women ($n = 1,375$)			*Risk-averse* ($n = 698$) **(2)**			*Risk-taker* ($n = 677$) **(2)**		
	Coef.	p-value	BW	Coef.	p-value	BW	Coef.	p-value	BW
$\underline{\text{LATE}}$ **(3)**	.5889	<.001	9.9	.2746	.278	8.6	.7382	<.001	9.0
$\overline{\text{LATE}}$ **(3)**	-.3909	.014	4.3	-.3068	.035	3.9	**(5)**	–	–
	Pap smears (1)								
	All women ($n = 1,349$)			*Risk-averse* ($n = 691$) **(2)**			*Risk-taker* ($n = 658$) **(2)**		
	Coef.	p-value	BW	Coef.	p-value	BW	Coef.	p-value	BW
$\underline{\text{LATE}}$ **(4)**	.3659	.163	4.9	**(5)**	–	–	.3443	.255	4.7
$\overline{\text{LATE}}$ **(4)**	-.3008	.080	5.3	-.1539	.455	8.3	-.1241	.520	4.2

Interpretation: Entering (respectively, exiting) the age period eligibility increases (decreases) by 73.82 percentage points (30.68 percentage points) the probability for respondents revealed as *risk-takers* (*risk-averse*) by the DOSPERT scale to undertake mammograms in time.

Notes: **(1)** Heteroskedasticity-corrected and robust estimation with covariates vector Z_i including: number of children, diploma, chronic condition, CHI coverage, financial difficulty, time preference, attitude toward risk (global DOSPERT score), local gynecologist density, local radiologist density. Covariates discontinuous at the cutoff excluded: CHI coverage and time preference ($\underline{\text{LATE}}$ mammograms), financial difficulty ($\overline{\text{LATE}}$ mammograms), attitude toward risk ($\underline{\text{LATE}}$ and $\overline{\text{LATE}}$ Pap smears). MSE-based optimal bandwidth (BW). **(2)** Respondents are classified as *risk-averse* (respectively, *risk-taker*) if their DOSPERT score is equal to or below (respectively, above) the median score (72, out of a total range of 30-210) of all respondents. Attitude toward risk excluded from covariates vector Z_i. **(3)** $\underline{\text{LATE}}$ and $\overline{\text{LATE}}$ estimated at the lower (age>50 years) and upper (age≥75 years) thresholds, respectively. **(4)** $\underline{\text{LATE}}$ and $\overline{\text{LATE}}$ estimated at the lower (age>25 years) and upper (age≥66 years) thresholds, respectively. **(5)** Not estimated due to insufficient observations.

-50pp for health-security risk, with financial risk-aversion being non-significant). However, the refined results from various specific domains at the lower cutoff of the eligible age period were not consistent with the positive but statistically non-significant discontinuity previously established with the global DOSPERT score. For three specific risk domains (social, health-security, and finance), the discontinuity at the lower cutoff was positive (ranging from +40pp to +54pp) and statistically significant at the conventional .05 level (slightly more for ethical risk). This result may be attributed to how the five specific domains are aggregated into the global DOSPERT score and, more importantly, to the possibility that respondents may express aversion to one particular risk whose contribution to the global DOSPERT score is mitigated by no aversion toward other risks, ultimately revealing no significant global risk-aversion. The refined measurement of risk attitudes exploring the five specific dimensions of the DOSPERT score provided no additional informative results concerning timely Pap smear uptake (Table 4 in Appendix).

Finally, we investigated potential heterogeneity in the *treatment* effect attributable to sociocultural and financial factors. We estimated discontinuities in the probability of being up to date with mammograms and Pap smears (Figures 4 and 5 in Appendix, respectively) by dichotomizing the respondent sample by educational attainment (A-level or below versus above A-level) and financial hardship status (reporting financial difficulties or not). Although these distinctions are crude (due to the difficulty of estimating *treatment* effects over small sub-samples, sometimes resulting in incalculable effects), they serve as markers to discriminate between individuals with different perceptions of health importance (education) or different approaches to health maintenance (financial constraints). The empirical evidence regarding potential discontinuities in mammogram uptake was more informative than that for Pap smears. Regardless of educational attainment, *risk-taking* respondents were positively and significantly affected by entering the eligible age period (diploma $\leq$ A-level: +141pp; diploma $>$ A-level: +74pp), unlike their *risk-averse* counterparts. The negative discontinuity at the upper cutoff previously identified for *risk-averse* respondents persisted but only for respondents with educational attainment at or below A-level (-34pp). Notably, reporting financial hardship did not substantially alter the increase in probability of being up to date with mammograms at the lower cutoff (+73pp for respondents reporting financial problems; +60pp for those without). Distinguishing women in precarious financial situations according to their risk attitude was not informative (effects were not statistically significant), unlike their non-precarious counterparts: the increase at the lower cutoff in the probability of having timely mammograms among women not reporting financial hardship (+60pp) was attributable to the most *risk-taking* individuals (+87pp). At the upper cutoff, situations were particularly contrasted depending on financial hardship status, with a significant decline (-56pp) among financially precarious respondents and, conversely, an increase among their counterparts without financial problems (+51pp), yet at the limit of the 5% statistical significance threshold. Among the latter group, however, the subsample of the most *risk-averse* exhibited the same but significant decline in the probability of being up to date with mammograms after exiting the eligible age period (-53pp).

We failed to find any statistically significant discontinuity in Pap smear uptake using the same estimation strategy. When estimates were computable, precision issues arose, partly due to subsample size constraints. Nevertheless, point estimates were generally oriented in the same direction as those found for mammograms. The only statistically significant discontinuity we observed was a 40 percentage point decrease in the likelihood of being up to date with cervical screening among women who reported no financial difficulties.

4 Discussion

4.1 Targeted screening programs and threshold effects

French national recommendations for regular breast and cervical cancer screening tests significantly improve compliance when respondents enter the age eligibility period. The probability for a woman to be up-to-date with mammograms increases significantly by nearly 59 percentage points (pp) after age 50. Similarly, after age 25, women show a 37pp increase in the probability of having had a timely Pap smear, though this effect is not statistically significant.

At the time of the survey, the breast cancer screening recommendation involved sending vouchers every two years to all women aged 50-74 for mammograms at any radiology practice. This nationally organized breast cancer screening campaign has undoubtedly contributed to reducing socioeconomic inequalities in access since its implementation in 2004 (Buchmueller and Goldzahl, 2018), with potential spillover effects on screening tests for other cancers (Dugord and Franc, 2022). Despite the existence of opportunistic screening before age 50 and after age 74 (estimated at 36% for women aged 40-49 and 13% for women aged 75-84 by Quintin et al. (2022)), we found strong discontinuity effects at both the beginning and end of the age period targeted by the national breast cancer screening campaign. This suggests the campaign can be viewed as relatively efficient, though the probability of being up-to-date with mammograms does not reach unity. The slightly smaller discontinuity observed at the end of the eligible age period raises important questions about the persistence of prevention habits among older women and must be considered in light of cost-effectiveness ratios and benefit-risk balance considerations (Boer et al., 1995).

Regarding Pap smears, the recommendation at the time of the survey was to invite women from age 25 to have a test every three years with a gynecologist, general practitioner, or midwife, with no specific financial support provided at the national level and under the same financial arrangements as ordinary health care. Thus, cervical cancer screening was mostly opportunistic in France until 2018 (Woronoff et al., 2019), with one-tenth of women aged 15-65 years having at least one annual Pap test being under age 25 (mainly aged 20-24) (Maura et al., 2018), before a scheme comparable to breast cancer screening was implemented the following year (Hamers et al., 2022). This may explain why we found no statistically significant threshold at the lower cutoff among survey respondents, whereas we observed the same drop at the upper cutoff in the probability of being up-to-date with Pap tests as for mammograms, though with smaller statistical significance.

We found no statistically significant discontinuity in timely Pap smear uptake in relation to reported financial hardship, either at the lower or upper cutoff. This does not imply the absence of financial inequalities in Pap smear uptake, but rather that national recommendations do not generate significant changes (neither increases nor decreases) in the probability of being up-to-date with testing that would vary according to financial status. By contrast, while there is strong evidence of a positive discontinuity in timely mammogram uptake for respondents entering the eligibility period—regardless of whether they reported financial problems—discontinuities exhibit opposite signs when exiting the eligibility period: negative for respondents with financial problems and positive for those without financial difficulties. While the national breast cancer screening program appears to successfully eliminate potential inequalities in mammogram uptake driven by adverse financial conditions at the lower cutoff, it conversely fails to maintain this effect at the upper cutoff. These findings nuance the established relationship between preventive care use and financial considerations, which typically shows under-screening among economically disadvantaged European women and over-screening among affluent ones (Quintal and Antunes, 2022). In France, Pap smear uptake has been found to be more sensitive to financial barriers than mammogram uptake (Menvielle et al., 2014). Pap smears are undoubtedly simpler to perform and less costly than mammography, requiring resources that are more geographically widespread. This accessibility may offset the fact that mammograms are provided free of charge while Pap smears must be paid for upfront (and subsequently reimbursed, either partially or fully, depending on the healthcare provider's billing arrangements). Breast and cervical cancer screening rates have been shown to be higher in large urban areas, as have social inequalities in test uptake within the recommended age groups (Ouanhnon et al., 2022). Outside the recommended age groups for mammography, social and territorial inequalities become even more pronounced, suggesting that screening test uptake may also be explained by non-price factors. These include social representations among the women concerned—which we were unable to document adequately using a crude variable such as educational attainment—and healthcare professionals' practices regarding the relative importance of continuing disease prevention beyond a certain age.

4.2 Attitudes toward risk and compliance with screening recommendations

The profile of *compliers* to the recommendations certainly warrants examination. Einav et al. (2020) convincingly demonstrated that women who begin mammograms at the entrance of the eligibility period due to a recommendation (the so-called *compliers*) are less likely to have breast cancer than women who self-select into screening earlier (the *always-takers*). This is likely why, when stratifying the treatment effect by attitude toward risk, there is no statistically significant threshold effect for the most *risk-averse* women who may have already undergone screening tests before the age of eligibility. *Compliers* are also more health-conscious (more likely to get other tests) than *never-takers*. Our results support this view, as the most *risk-averse* women likely undertake breast (and presumably cervical) cancer screening tests before the beginning of the eligibility period. Like the conclusions of Einav et al. (2020), this requires public health policymakers to question *who* responds to screening recommendations and not just *how many*, and as a result, to address the heterogeneity in cancer risk and screening response with more targeted or personalized screening recommendations.

At first glance, cancer screening tests should mainly be undertaken by *risk-averse* women (because they dislike uncertainty), independent of other individual characteristics such as higher self-rated health or socioeconomic status (Satoh and Sato, 2021). The summary statistics and the associated inference tests given in Table 1 give empirical evidence for timely uptake of mammograms and pap smears higher among the most *risk-averse* respondents in- and out-of-target except for out-of-target Pap smears. Yet, the way targeted screening programs impact adherence to the recommendations, though the discontinuities in uptake they may cause, is not strictly superimposable to what the summary statistics allow us to learn. The reason is that the relationship between attitude toward risk and uptake of cancer screening tests is ambiguous, depending on the concavity of the utility function (Picone et al., 2004). Indeed, screening tests create value through two opposing mechanisms that affect *risk-averse* women in opposite ways. First, screening reduces expected losses from illness through early detection, making *risk-averse* women more likely to take tests up than risk-neutral counterparts for this protective benefit. However, when screening reveals illness, it presents a treatment *gamble* (as stated by Picone et al. (2004)) involving certain costs with only probabilistic success. *Risk-averse* women value this uncertain treatment opportunity less than risk-neutral women, reducing their willingness to test for this aspect of screening. Thus, risk aversion simultaneously increases the value of screening's protective function while decreasing the value of the treatment options it may reveal, with effects eventually distorted by women's position in the distribution across socioeconomic statuses (von Wagner et al., 2011). This ambiguity is supported by empirical studies which found either weak negative correlations (Picone et al., 2004; Goldzahl, 2017; Wu, 2003) or no significant relationships between risk aversion and screening behavior. The results we obtained, when stratifying the discontinuity estimates by attitude toward risk, provide empirical evidence for the absence of relationship between risk aversion and screening test uptake concerning mammograms at age 50 and Pap smears at age 25, possibly because of the mechanism theorized by Picone et al. (2004). At the same time, we found a strongly positive and statistically significant discontinuity effect at age 50 in the uptake of mammograms among *risk-taking* women. *Risk-taking* women may then underweight or be less deterred by the immediate costs and discomforts associated with mammograms and be more comfortable with uncertainty and less anxious about potential negative results. They may focus more on the potential benefits of early detection rather than dwelling on treatment-related concerns, with the psychological cost of *not knowing* their health status being lower than for their *risk-averse* counterparts. This would explain why *risk-taking* women actually show stronger uptake of mammograms when screening becomes available. The eligibility threshold thus serves as a clear action trigger for women who are otherwise comfortable with health uncertainty but responsive to explicit policy signals. The discontinuity effect we found among *risk-takers* might thus reflect their willingness to act decisively once screening becomes officially recommended, unburdened by the anticipatory anxiety that might cause *risk-averse* women to delay or avoid screening altogether.

Conversely, regarding mammograms, a strong negative and statistically significant discontinuity emerges at the upper cutoff of the age eligibility period for the most *risk-averse* respondents (a 31pp drop in the probability of being up-to-date with the recommended biennial test). Combined with our previous findings, this result supports the hypothesis that when aging and exiting the age period targeted by recommendations, the utility derived by the most *risk-averse* women from mammogram-induced reduction in expected losses due to early breast cancer diagnosis falls below the disutility associated with the consequences and potential outcomes of subsequent treatment. This finding resonates with the public health debate regarding the relevance of cancer screening recommendations for the elderly, where the risk-benefit balance remains poorly identified for many cancers, leading to individualized screening decisions that align with patients' expectations and preferences (Breslau et al., 2016). In the case of colorectal cancer screening, Taksler et al. (2017) demonstrated that risk aversion inclines individuals to undergo fewer (at most two) and less frequent (20 years apart) tests during their lifetime, with reduced life expectancy benefits. Disentangling the contributions of risk attitudes from social representations (captured through educational level) or financial constraints allows us to refine our understanding of discontinuities in timely mammogram uptake. Unlike their counterparts with post-secondary education, the most *risk-averse* respondents with at most secondary-level education exhibit a significant negative discontinuity (-34pp) when exiting the eligible age period. This supports the hypothesis that *risk-averse* women with lower educational attainment tend to underestimate the importance of continuing screening tests, thereby strictly adhering to official recommendations. Notably, the most *risk-averse* respondents without reported financial problems also demonstrate a negative discontinuity in timely mammogram uptake when exiting the eligibility period (-53pp), whereas the most *risk-taking* respondents without financial hardship exhibit a strong positive discontinuity when entering the eligibility period (+87pp). These results highlight how risk attitudes may differentially impact discontinuities caused by targeted screening programs—at least for mammograms—depending on respondents' social or economic status.

4.3 Limits

Unfortunately, it was not possible to enrich the results by disentangling attitude toward risk and risk perception in this survey, whereas it has been previously proven that this may refine the results relating the decision to test and the attitude toward risk. Thus, on the basis of a laboratory experiment carried out with women aged 50-75 in France in 2013, Goldzahl (2017) found that risk aversion contributed to 30% of the variance in the regularity of breast cancer screening. Meanwhile, improving risk perception by 10% resulted in a 5% increase in the probability to have a mammogram regularly. Health risk misperception is a non-price determinant that may explain why people engage in risky or preventive behaviors (Lairson et al., 2005), so that risk aversion *per se* could have a much smaller contribution to the decision to screen than one might legitimately expect (Riddel and Hales, 2018). Light manipulations of the perception of screening importance based on the presentation of invitation letters for mammograms have not been found to cause significant changes in screening rates in a French randomized controlled experiment (Goldzahl et al., 2018). However, in a similar field experiment carried out in Italy, emphasizing the losses induced by non-uptake increased mammogram uptake, especially among women with the lowest baseline screening rates (Bertoni et al., 2020).

Of course, the lessons to take from this paper are tempered by some considerations, at the top of which the measurement of the timely realisation of the screening tests, which was reported by the respondents and not taken from medical records or health insurance reimbursement files. Because of memory, dissimulation or social desirability biases, the gap between self-reported and actual utilisation of cancer screening tests can be consistent. Based on a meta-analysis from 37 papers, Howard et al. (2009) estimated the women's report of timely mammograms (respectively, Pap smears) matches 65 to 89% of times (respectively, 65 to 97%) with medical records. For instance, Cronin et al. (2009) estimated that women over-estimated by 15 to 25% the mammography use in the last two years in Vermont and Bowman et al. (1997) found an over-report of Pap smears by more than one-third compared to laboratory data in Australia. If reducible to observable individual characteristics, those biases must be controlled for when estimating discontinuities in the screening tests uptake. That is the reason why covariables documenting some of those characteristics were introduced in the regressions as well as why regressions were also stratified according to the variables available in the survey supposed to be related with the socio-economic status. In addition, we used the DOSPERT scale to describe the respondents' attitude toward risk, the five dimensions of which have been competitively used all together and separately in order to determine whether discontinuities in screening tests uptake are associated with a global pattern of attitude toward risk or are domain-specific, as processed in Weber et al. (2002) or Bapna et al. (2010). In this respect, in spite of the DOSPERT scale psychometric properties (Shou and Olney, 2020), using the median global score or the domain-specific scores to dichotomize the sample into more or less *risk-averse* respondents may appear unusual compared to the way respondents proposed with lotteries usually choose between a hypothetic gain and its certain equivalent within an expected utility design (O'Donoghue and Somerville, 2018).

5 Conclusion

Unsurprisingly and reassuringly, cancer screening test uptake rates are substantially higher among age groups targeted by national public health policy, regardless of the intervention format (vouchers for free mammograms at radiology centers or recommendations for Pap smears by gynecologists or general practitioners). However, these rates remain suboptimal and, even among women targeted by the policy, fall short of national objectives. More importantly, public health policy provisions have symmetric effects on screening decisions—dramatically increasing screening probability during the early target age period while decreasing it at the end—and fail to establish permanent beneficial health behaviors from a comprehensive life-course perspective. These policies do not appear to differentially impact the probability of having timely tests based on educational level or financial constraints, except for women expected to undergo mammography at the upper cutoff of the eligible age period, where those facing the greatest financial constraints (respectively, the least financial constraints) are negatively (respectively, positively) affected by the end of eligibility for free testing.

Notably and originally, these policies appear to specifically motivate the most *risk-taking* women to complete mammograms on time, whereas their most *risk-averse* counterparts are particularly likely to discontinue testing after exiting the targeted age period. Given that the most *risk-averse* women tend to undergo screening tests more frequently than their most *risk-taking* counterparts outside the eligibility periods established by public health authorities, the substantial increase in test uptake among the latter can be interpreted as a catch-up effect—though insufficient to equalize the proportions of women up-to-date with their mammograms. Nevertheless, the heterogeneity in screening test discontinuities based on individual risk attitudes argues against one-size-fits-all policies and in favor of adapting nationally organized screening campaigns and public health authority recommendations to the specific needs of targeted women based on their underlying personality traits.

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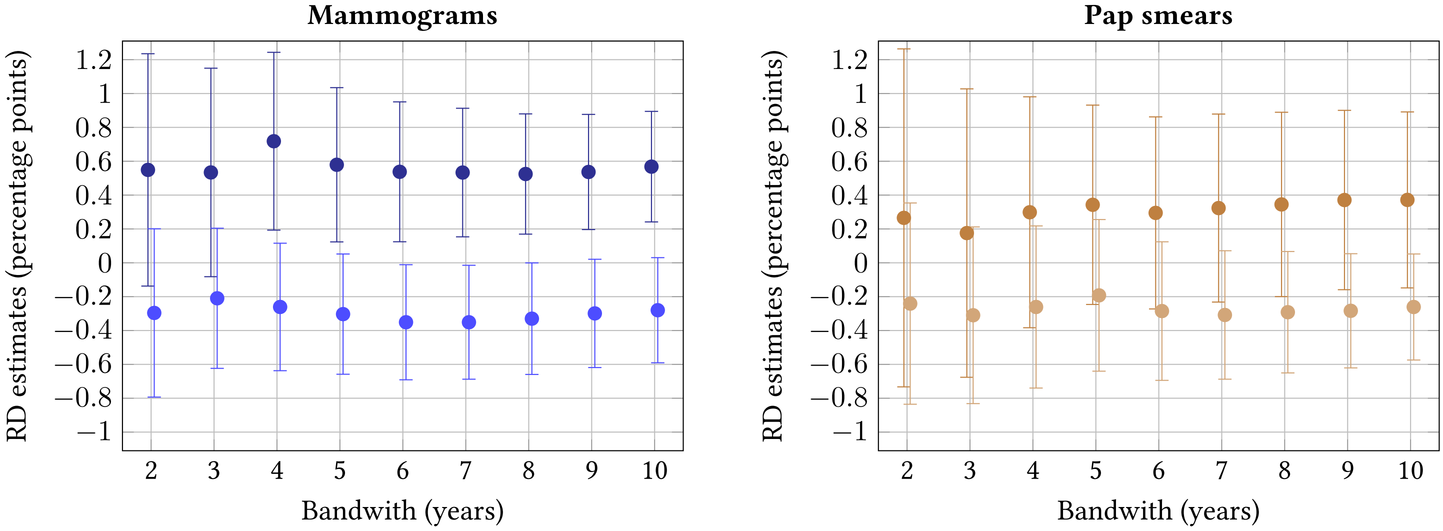
Appendix

Figure 3. $\underline{\text{LATE}}$ and $\overline{\text{LATE}}$ RD estimates of mammogram and Pap smear uptake at lower (top panels) and upper (bottom panels) eligibility cutoffs, by bandwith (marginal effect; percentage point estimates and 95% CI)



Lecture: Within a 10-year bandwidth around the 50-year cutoff, invitation to free mammography screening by public health authorities increases screening uptake by 56.81 percentage points (95% CI: 24.16pp to 89.46pp). Similarly, within a 10-year bandwidth around the 75-year cutoff, cessation of free mammography invitations decreases screening uptake by 28 percentage points (95% CI: -59.04pp to 3.05pp).

Table 3. $\underline{\text{LATE}}$ and $\overline{\text{LATE}}$ estimates for timely mammograms, by attitude toward risk (DOSPERT domain-specific dimensions)

	Health-security (1)				**Finance (1)**			
	Risk-averse (2) ($n = 752$)		*Risk-taker* (2) ($n = 623$)		*Risk-averse* (2) ($n = 726$)		*Risk-taker* (2) ($n = 649$)	
	Coef.	p-value	Coef.	p-value	Coef.	p-value	Coef.	p-value
$\underline{\text{LATE}}$ **(3)**	.4390	.021	.7798	<.001	.5434	.002	.5927	.003
$\overline{\text{LATE}}$ **(3)**	-.5032	.002	**(4)**	–	-.2030	.151	-.0294	.912
	Social (1)				**Ethics (1)**			
	Risk-averse (2) ($n = 709$)		*Risk-taker* (2) ($n = 666$)		*Risk-averse* (2) ($n = 700$)		*Risk-taker* (2) ($n = 675$)	
	Coef.	p-value	Coef.	p-value	Coef.	p-value	Coef.	p-value
$\underline{\text{LATE}}$ **(3)**	.4337	.042	.7545	<.001	.3999	.084	.6652	.002
$\overline{\text{LATE}}$ **(3)**	-.3995	.018	**(4)**	–	-.4136	.003	.0220	.919
	Recreational (1)				**All domains (1)**			
	Risk-averse (2) ($n = 709$)		*Risk-taker* (2) ($n = 666$)		*Risk-averse* (2) ($n = 700$)		*Risk-taker* (2) ($n = 675$)	
	Coef.	p-value	Coef.	p-value	Coef.	p-value	Coef.	p-value
$\underline{\text{LATE}}$ **(3)**	.1663	.500	.8086	<.001	.2746	.278	.7382	<.001
$\overline{\text{LATE}}$ **(3)**	-.2795	.066	**(4)**	–	-.3068	.035	**(4)**	–

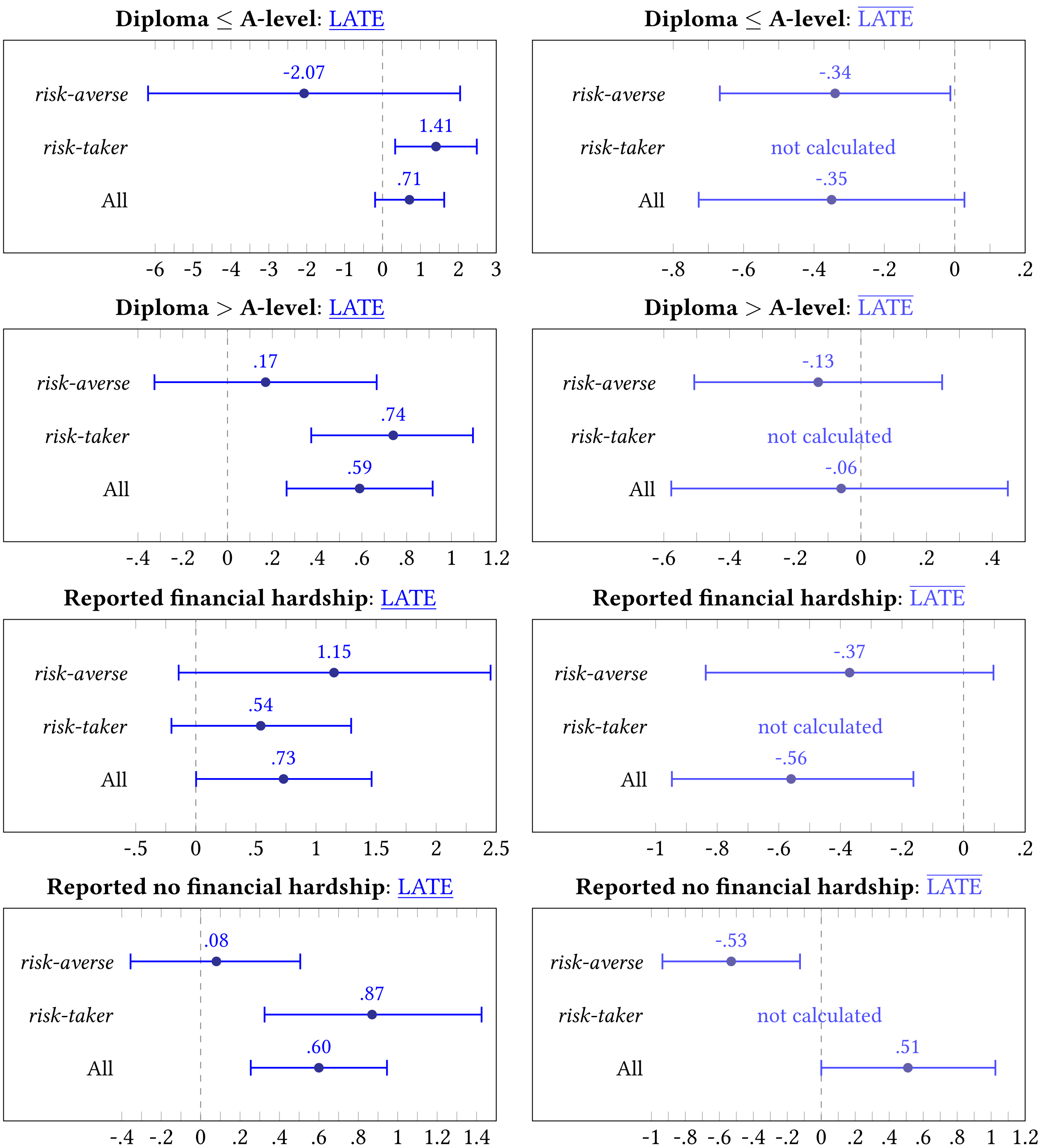
Notes: **(1)** Heteroskedasticity-corrected and robust estimation with covariates vector Z_i including: number of children, diploma, chronic condition, CHI coverage, financial difficulty, time preference, local gynecologist density. Covariates discontinuous at the cutoff excluded: CHI coverage and time preference ($\underline{\text{LATE}}$), financial difficulty ($\overline{\text{LATE}}$). MSE-based optimal bandwidth (BW). **(2)** Respondents are classified as *risk-averse* (respectively, *risk-taker*) if their DOSPERT score is equal to or below (respectively, above) the median score of all respondents. **(3)** $\underline{\text{LATE}}$ and $\overline{\text{LATE}}$ estimated at the lower (age$>$50 years) and upper (age$\geq$75 years) thresholds, respectively. **(4)** Not estimated due to insufficient observations.

Table 4. $\underline{\text{LATE}}$ and $\overline{\text{LATE}}$ estimates for timely Pap smears, by attitude toward risk (DOSPERT domain-specific dimensions)

	Health-security (1)				**Finance (1)**			
	Risk-averse **(2)** ($n = 743$)		*Risk-taker* **(2)** ($n = 606$)		*Risk-averse* **(2)** ($n = 712$)		*Risk-taker* **(2)** ($n = 637$)	
	Coef.	p-value	Coef.	p-value	Coef.	p-value	Coef.	p-value
$\underline{\text{LATE}}$ **(3)**	.4620	.142	.4719	.125	.3455	.457	.0033	.992
$\overline{\text{LATE}}$ **(3)**	-.2200	.278	-.1177	.582	-.2572	.190	-.0710	.703
	Social (1)				**Ethics (1)**			
	Risk-averse **(2)** ($n = 696$)		*Risk-taker* **(2)** ($n = 653$)		*Risk-averse* **(2)** ($n = 694$)		*Risk-taker* **(2)** ($n = 655$)	
	Coef.	p-value	Coef.	p-value	Coef.	p-value	Coef.	p-value
$\underline{\text{LATE}}$ **(3)**	**(4)**	–	.0950	.767	**(4)**	–	.4772	.156
$\overline{\text{LATE}}$ **(3)**	-.1335	.506	.0214	.885	-.3047	.131	-.0538	.840
	Recreational (1)				**All domains (1)**			
	Risk-averse **(2)** ($n = 705$)		*Risk-taker* **(2)** ($n = 644$)		*Risk-averse* **(2)** ($n = 691$)		*Risk-taker* **(2)** ($n = 658$)	
	Coef.	p-value	Coef.	p-value	Coef.	p-value	Coef.	p-value
$\underline{\text{LATE}}$ **(3)**	.2952	.257	.4920	.104	**(4)**	–	.3443	.255
$\overline{\text{LATE}}$ **(3)**	-.1803	.170	**(4)**	–	-.1539	.455	-.1241	.520

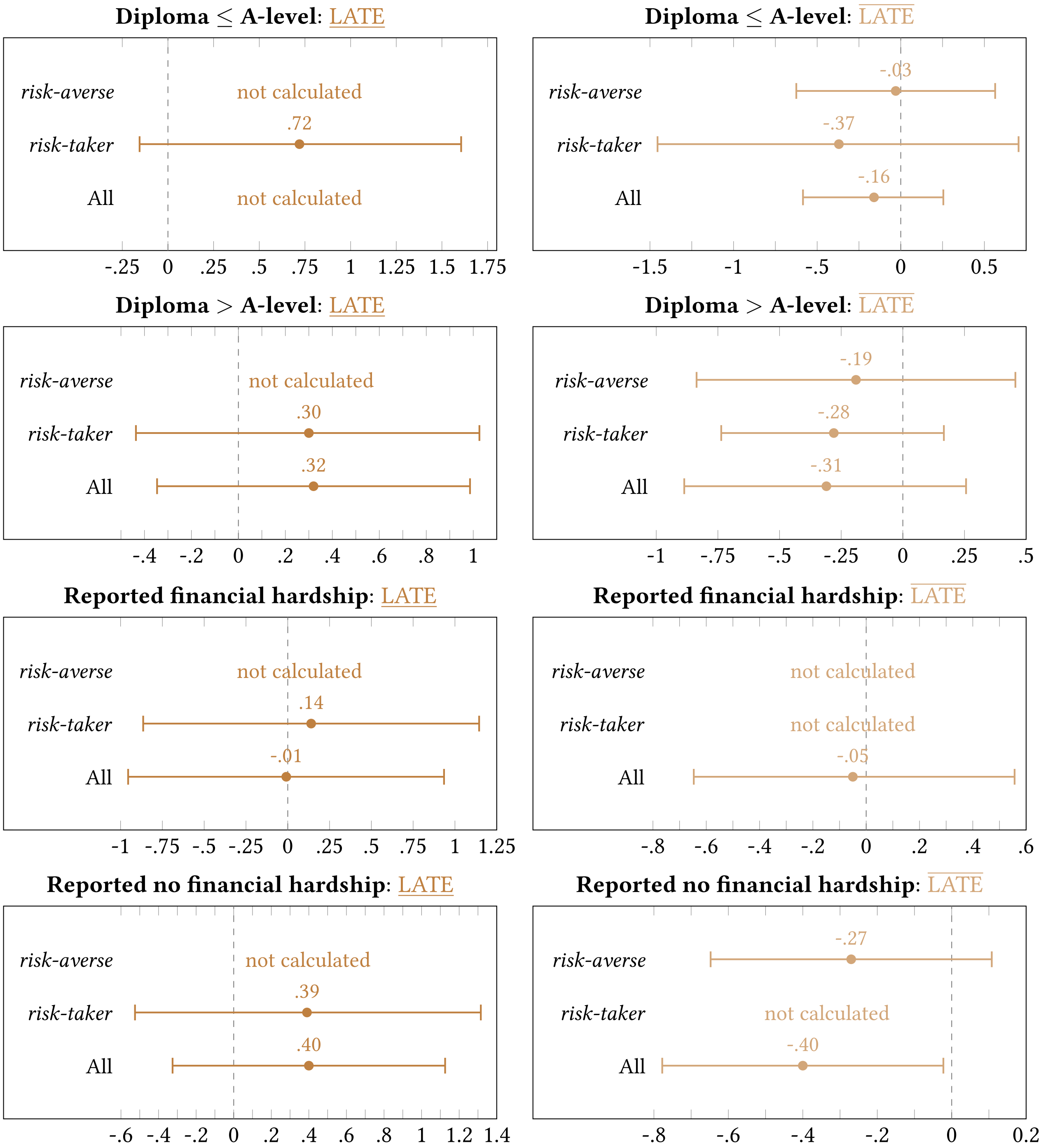
Notes: **(1)** Heteroskedasticity-corrected and robust estimation with covariates vector Z_i including: number of children, diploma, chronic condition, CHI coverage, financial difficulty, time preference, local radiologist density. MSE-based optimal bandwidth (BW). **(2)** Respondents are classified as *risk-averse* (respectively, *risk-taker*) if their DOSPERT score is equal to or below (respectively, above) the median score of all respondents. **(3)** $\underline{\text{LATE}}$ and $\overline{\text{LATE}}$ estimated at the lower (age$>$25 years) and upper (age$\geq$66 years) thresholds, respectively. **(4)** Not estimated due to insufficient observations.

Figure 4. LATE and $\overline{\text{LATE}}$ RD estimates of timely mammogram at lower (left) and upper (right) eligibility cutoffs, by diploma and reported financial hardship (marginal effect; percentage point estimates and 95% CI)



Heteroskedasticity-corrected and robust estimation with covariates vector Z_i including: number of children, chronic condition, CHI coverage, time preference, local radiologist density, local gynecologist density.
Covariates discontinuous at the cutoff excluded: CHI coverage and time preference (LATE).
Respondents are classified as *risk-averse* (respectively, *risk-taker*) if their DOSPERT score is equal to or below (respectively, above) the median score (equal to 72) of all respondents.
LATE and $\overline{\text{LATE}}$ estimated at the lower (age>50 years) and upper (age≥75 years) thresholds, respectively.

Figure 5. $\underline{\text{LATE}}$ and $\overline{\text{LATE}}$ RD estimates of timely Pap smears at lower (left) and upper (right) eligibility cutoffs, by diploma and reported financial hardship (marginal effect; percentage point estimates and 95% CI)



Heteroskedasticity-corrected and robust estimation with covariates vector Z_i including: number of children, chronic condition, CHI coverage, time preference, local radiologist density, local gynecologist density.
Covariates discontinuous at the cutoff excluded: CHI coverage and time preference ($\underline{\text{LATE}}$).
Respondents are classified as *risk-averse* (respectively, *risk-taker*) if their DOSPERT score is equal to or below (respectively, above) the median score (equal to 72) of all respondents.
$\underline{\text{LATE}}$ and $\overline{\text{LATE}}$ estimated at the lower (age>25 years) and upper (age≥66 years) thresholds, respectively.