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RESEARCH

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Individual well-being and national determinants of screening mammography among women over fifty

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Abstract

Background Breast cancer is the most prevalent cancer among women worldwide, causing over 400,000 cases of premature death annually. Timely screening mammography (SM) could have prevented most death. Although SM utilization varies across countries, few studies have examined country-level factors, and fewer explored their interaction with individual-level factors. The study aims to analyze individual and country-level variables and their interaction that determines SM utilization and variation between countries.

Methods Individual, country, and cross-level models are used to analyze the cross-sectional data from the SHARE database for 26,672 women aged 50 or over, from 27 countries. Key individual variables investigated include quality-of-life (QOL), psychological, and subjective-health status. Country-level variable included government health expenditure (GHE) percentage of GDP, and organized screening programs. Models were adjusted for individual variables such as age and education.

Results Self-reported SM utilization varied from 5 to 67% in the countries examined. On the individual level, higher QOL, psychological, and subjective health status positively correlated with SM utilization, as did GHE and organized programs on the country-level. Surprisingly, the interaction between individual and country-level variables shows that while SM utilization positively correlates with higher psychological and subjective health status in high-GHE countries, it negatively correlates in low-GHE countries, and only weakly positive correlates in mid-level GHE countries.

Conclusions Better individual well-being, both physical and psychological, increased SM utilization, as did higher GHE and countrywide SM programs. The negative correlations in low-GHE countries and positive correlations in high-GHE countries underscores disparities that need to be addressed.

Keywords Breast cancer, Depression, Health expenditure, Multilevel analysis, Quality of life, Screening mammography, Subjective-Health

Background

Breast cancer is the most prevalent type of cancer among women worldwide, with nearly 6 million cases in 2020 (29.8% of total cancer cases among women). It is also the second-most lethal cancer worldwide after lung cancer, with over 550,000 deaths (14.5% of cancer deaths among women) [1, 2]. Ginsburg and colleagues recently estimated that over 436,000 women die prematurely of breast cancer each year and estimate that over 60% of death cases could be avoided if all women had access to early

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detection [3]. Early breast cancer diagnosis increases survival rates and reduces the need for challenging treatments with severe side effects. Approximately 51.5% of breast cancer patients over the age of 50 were diagnosed at an early stage in OECD countries between 2010 and 2014 (although there is significant variation across countries) [4, 5]. The main tool for early diagnosis is screening mammography (SM) which involves an X-ray exam of the breast and is considered the best way to diagnose breast cancer at an early stage [6]. According to the United States Preventive Services Task Force, SM is recommended biannually for women aged 40–74 [7]. Similarly, the European Union breast cancer guidelines recommend a biannual SM for women aged 50 to 69 while women aged 45–49 with average risk should screen every 2–3 years and women aged 70–74 should screen every 3 years [8].

Previous studies have examined potential factors that affect SM utilization in women over 50, either at the individual or country/health system level. These include knowledge about SM [9–14], higher education and verbal skills [9–11, 15, 16], socio-economic status, employment status and medical insurance coverage [9–11], age and health status [11, 17], and quality-of-life [18], all of which increase the likelihood of having SM. In contrast, psychological factors such as anxiety, cancer fatalism, embarrassment, mistrust, and fear reduce the likelihood of having SM [9, 11, 18, 19]. While the difference in SM utilization between countries is large, little research has compared country-level determinants of SM utilization, such as consumers' side payments, which depend on, among others, insurance coverage. Out-of-pocket payments and financing concerns were previously reported to decrease SM utilization, [12, 18, 20–22] while the elimination of out-of-pocket and cost-sharing, through increased public health expenditure increases it [23, 24]. On the same note, organized national screening programs were found to increase SM utilization and decrease breast cancer mortality [15, 25, 26], with major differences between high income countries and low and middle income countries [26, 27].

The current study contributes to scientific literature by adopting a two-level approach to analyzing SM utilization between countries: the first level examines individual factors, while the second focuses on country-level factors. At the individual level, we consider subjective well-being factors as identified in the SHARE study, including an individual's quality of life, psychological well-being, and health status. These factors may influence health-seeking behaviors, potentially decreasing the likelihood of engaging in preventive measures such as mammography.

At the country level, we include factors such as total health expenditure, government health expenditure, and organized screening programs strategy; these factors are expected to increase access to and utilization of preventive services like SM. The opposing directions of effect at the individual and country levels underscore the importance of cross-level interaction analysis to estimate the inter-country variability of individual variables.

The study objective is to identify individual/country characteristics that may increase SM utilization, and which warrant attention from public health policymakers.

Methods

The study used individual-level data and country-level data. Individual-level data was obtained from the micro-level Pre-Covid Wave 8 (2019–2020) of the Survey of Health, Ageing and Retirement in Europe (SHARE, Release 8.0.0) [28], a cross-sectional research established for studying the effects of health, social, economic, and environmental policies over the life-course of European citizens. The data is based on interviews held between October 2019 and March 2020 with 26,672 women aged 50 + from 27 countries.

Study participants—While medical guidelines suggest performing SM for average-risk women until the age of 74 at different intervals, 14% of the participants in the study who underwent SM were 75 years or older. As we did not wish to ignore this age group, they were included in the analysis. To make sure that our findings adhere with other studies, focusing on women aged 50–69 (when biannual SM is recommended), we ran a separate analysis of this group ($N = 13{,}288$). The results (Supplementary Table 1) were consistent with those from the broader age group, with minor variations observed.

Based on data from the SHARE Sample Management System using Release 8.0.0 (SHARE, Release 8.0.0) [28], the SHARE target population comprises all individuals aged 50 years and older at the time of sampling who reside in their regular domicile within a SHARE country. Exclusions apply to individuals who are incarcerated, hospitalized, or out of the country for the entire survey period, as well as those unable to speak the country's language(s) or whose address is unknown. In Wave 8, individuals born in 1969 or earlier were eligible for an interview. The Wave 8 sample consisted of two components: a longitudinal subsample and a refreshment subsample. The longitudinal subsample included respondents who had participated in any previous wave of the study. The refreshment subsample, on the other hand, consisted of new sample units drawn in Wave 8 to ensure representation of younger cohorts who were not age-eligible in earlier waves (i.e., individuals born between 1967 and 1969) and to offset sample size reductions due to attrition over the course of the SHARE panel.

Country-level data—was obtained from the OECD Health Statistics Library (OECD-stat) [29], a comprehensive source of comparable statistics for the OECD, which was merged with the SHARE data. Data was gathered for 2019 or the nearest available year. Country level breast cancer screening program strategy (Country programs) was evaluated based on data by Ponti and colleagues [30] Willems and colleagues [16], Jolidon and collegues [24], Tur-Sinai and Shaharabani [31] and Billiard and collegues [32] to cover all the countries participating in the SHARE study.

The outcome variable is a self-reported SM test, which is a binary variable that takes a value of 1 if a respondent reported having a mammogram during the two years before the interview and 0 otherwise. The exposure variables included three indexes of individual well-being from SHARE: The first is the CASP-12 index of quality-of-life (QOL) in older age, a theoretically grounded measure of quality of life in older age. It is composed of four subscales: Control, Autonomy, Self-realization, and Pleasure, each presented as questions or statements on a four-point Likert scale ("often," "sometimes," "rarely," "never"). The resulting score ranges from 12 (poor QOL) to 48 (high QOL) [33]. The second is the EURO-D index of depression which was developed as a common depression symptoms scale based on 12 metrics of late-life depression: depression, pessimism, suicidality, guilt, sleep, interest, irritability, appetite, fatigue, concentration, enjoyment, and tearfulness [34]. The resulting score ranges from 0 (not depressed) to 12 (very depressed). Our analysis used a *reversed score*, referred to as EURO-Dr, in which 0 is very depressed and 12 is not depressed. The third is the Subjective-Health index in which SHARE participants are asked to rank their health between 1 (excellent) and 5 (poor). Our analysis used a *reversed score*, referred to as SHr, in which 1 is poor health and 5 is excellent health.

Individual-level explanatory variables included the participant's age, years of education, number of chronic diseases and unmet needs, a binary variable which takes a value of 1 for individuals who reported at least one of the following: (1) their household is able to make ends meet only with great difficulty or with some degree of difficulty; (2) during the past year they have kept their homes cold in order to save on heating costs; or (3) they had forgone care from a general practitioner or a specialist physician, drug treatment, dental care, optical care, home care, paid home help or some other medical care during the previous year.

Country-level variables included two OECD expenditure measures [4], and the country breast cancer screening program strategy (Country programs) developed by Willems and colleagues [16]. Total health expenditure (THE_of_GDP) and government health expenditure (GHE_of_GDP) were used as percentage of GDP. Country programs variable was ranked 2 when the programs were nationally organized, providing universal coverage to all eligible women; ranked 1 when the programs were region based, and ranked 0 when there was no country screening strategy, leading to opportunistic screening behavior. While most countries in the SHARE study had organized country programs, Austria, Portugal, Slovenia, and Switzerland had regional country programs and the Slovak Republic, Bulgaria and Romania had opportunistic strategy. It is important to note the uneven distribution of screening programs: while 19,704 participants lived in countries with organized programs, only 3,521 participants lived in countries with opportunistic screening programs, and 3,447 in countries with regional screening programs.

As the findings for GHE and Country programs demonstrated similar behavior in models 2 and 3, we used ANOVA between groups analysis to look for their interaction, that demonstrated high and significant difference between countries with opportunistic screening programs (average GHE = 4.92% of GDP) and countries with regional and organized programs (average GHE = 7.06% and 6.82% of GDP accordingly). These findings suggest a positive correlation between the structure of screening programs and government health expenditure, indicating that more organized screening programs are associated with higher health spending (Supplementary Table 2).

Missing data—Out of a total of $N = 26{,}672$ women aged 50 and above, only $n = 181$ women had missing data for the SM question. For subjective health, there were $n = 51$ missing values, and for EURO-D, $n = 881$ missing values. The only variable with more than 5% missing data was CASP ($n = 2{,}160$), due to the absence of this variable for Romanian. As a result, we excluded Romania from the analysis of the CASP model, leaving us with 26 countries in this model.

Statistical methods

We applied a multilevel approach using a data structure consisting of individuals (level 1) nested within countries (level 2). Three sequential equations were estimated for each of the three models, one for each of the exposure variables (CASP, EURO-Dr, and SHr):

Model-1: A fixed-effect estimation of individual-level variables allowing for a random intercept by country.
Model-2: Model-1 with country-level variables added to capture the fixed effect of healthcare expenditure/screening program.
Model-3: Model-2 with the interaction of the exposure variable and the country variable added. This

makes it possible to examine within-country variability according to the inter-country variability.

The analysis focused on two sources of variation in addition to the fixed effects: *intercept variation* which reflects the degree to which countries differ in the mean value of SM rates; and *variation in the slope* of the exposure variables. We adopted a cautious multilevel approach to potential challenges associated with country effects. Specifically, this involved focusing on randomly selected women aged 50 and over, a representative country sample, and a harmonized final dataset. Furthermore, the study encompasses 27 countries, with a sample size for each country ranging from 300 to 1,700 women. These features provide confidence in the validity of the results.

The regression equations were GLM binomial with a logit link and were estimated using restricted maximum likelihood (REML) [35–37]. For each regression, we calculated the random effect parameters, the adjusted intraclass correlation (ICC), the Akaike Information Criterion (AIC), and the ratio between the Marginal R-squared, which measures only the variance of the fixed effects, and the Conditional R-squared, which measures both the fixed and random effects [35, 36]. The hypothesis that the intercept variance is not significantly different from zero was tested by comparing the -2 log-likelihood difference between a model with a random intercept and one with a non-random intercept. The variance of the random effect slope and the correlation between the random intercept and the random slope were calculated for Models 2 and 3. The analysis was performed using R Software (version R–4.2.2) while the multilevel analysis was conducted using several R-Packages (Supplementary Table 3) and followed the customary procedure of analysis [36, 38].

Results

The sample consisted of 26,672 women aged 50 + residing in 27 countries. Their mean age was 70.7 years with an average of 11 years of education and 2 chronic diseases (Table 1). The average scores of the exposure variables were 37.2 for CASP, 9.2 for EURO-Dr, and 2.7 for SHr.

Almost 44% of participants reported having undergone SM, with substantial variation between countries (from 5% in Romania to 67% in the Czech Republic, see Supplementary Fig. 1). To eliminate the possibility that the between-group variance is the result of only one or two outlying countries, we examined the distribution of the intercepts. The resulting plot (Fig. 1) shows that SM rates varied across countries according to a random intercept ranging from -3.0 to + 1.3. As Romania and Bulgaria seemed to be outliers, we performed Rosner test for outliers on the dataset which individual are grouped by country. The test detected no outliers.

Next, we examined the SM rate by country. Figure 2 shows SM rates by country according to average CASP, EURO-Dr, and SHr scores. As shown, the CASP-QOL, EURO-Dr, and SHr scores positively correlate with SM, suggesting that high SM rates are observed in countries with high levels of individual well-being. This result was validated in the estimation of Model-1.

Table 1 Characteristics of the participants and their distribution by country

Characteristic:	**Overall (*N* = 26,672)**
Screening mammography = Yes	11,630 (43.9%)
CASP-12 score (12–48)	37.16 (SD = 6.2); (12;48)
EURO-Dr score (0–12)	9.24 (SD = 2.35); (0;12)
SHr score (1–5)	2.74 (SD = 1.02); (1;5)
Patient Age (years)	70.72 (SD = 9.58); (50; 100)
Years of education (years)	10.96 (SD = 4.11); (0;25)
Unmet needs	9,310 (34.9%)
Number of chronic diseases	2.01 (SD = 1.67); (0;14)
Country	**Participants (% of study)**
Austria	945 (3.5%)
Belgium	1105 (4.1%)
Bulgaria	540 (2.0%)
Croatia	669 (2.5%)
Cyprus	328 (1.2%)
Czech	1654 (6.2%)
Denmark	1170 (4.4%)
Estonia	1914 (7.2%)
Finland	619 (2.3%)
France	1446 (5.4%)
Germany	1532 (5.7%)
Greece	1715 (6.4%)
Hungary	473 (1.8%)
Israel	555 (2.1%)
Italy	1213 (4.5%)
Latvia	488 (1.8%)
Lithuania	895 (3.4%)
Luxembourg	520 (1.9%)
Malta	440 (1.6%)
Netherland	1053 (3.9%)
Poland	1153 (4.3%)
Romania	723 (2.7%)
Slovakia	543 (2.0%)
Slovenia	1465 (5.5%)
Spain	1209 (4.5%)
Sweden	1268 (4.8%)
Switzerland	1037 (3.9%)

Data are Mean (SD) (Minimum; Maximum) or n / N (%)

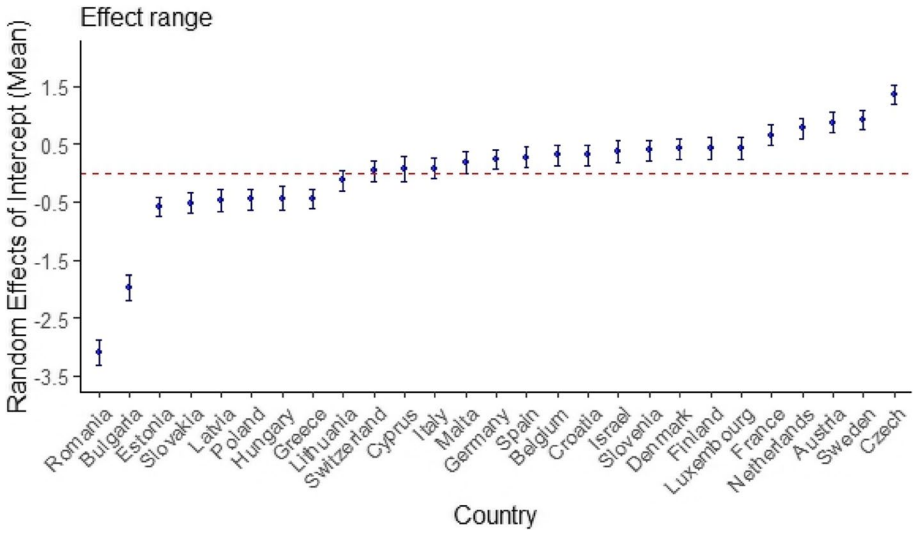

Fig. 1 Between country random intercept variation for Screening Mammography

Model 1 – Fixed effect estimation of individual-level variables while allowing for a random intercept by country

The results for Model 1 (Table 2) show that the estimated fixed effects of the individual-level variables were positive and significant, indicating that the likelihood of undergoing SM increases with individual well-being. SHr subjective-health score had an effect of OR = 1.10 on a scale of 1–5, CASP-QOL score had an effect of OR = 1.04 on a scale of 12–48, and the EURO-Dr psychological score had an effect of OR = 1.02 on a scale of 0–12 (scales are not comparable).

The estimated between-country variance, which captures the country of residence's contribution to the variation among women, was significant in all three equations. The ICC variability score was 0.10 for CASP (26 countries), and 0.19 for EURO-Dr and SHr (27 countries) indicating that the country of residence has a large effect on the variation in SM rates.

The intercept coefficient for each country produced by Model 1 of CASP, EURO-Dr and SHr, are presented in Supplementary Fig. 2.

Model 2 – Fixed effect estimation of country-level variables in addition to the individual-level variables while allowing for a random intercept by country

Model-2 added three country-level covariates (THE, GHE, and Country programs) to determine whether either of them is a significant predictor of the SM rate. Table 3 presents the estimation results (full models results are shown in Supplementary Table 4). Each of the country-level covariates was added separately given the high correlation between them. The estimation results for model 2 with interaction terms between GHE and Country programs presented in Supplementary Table 5.

CASP QOL index positively and significantly correlated with SM utilization for all country-level variables. GHE had a lower, yet more significant fixed effect on QOL. Compared with countries with opportunistic breast cancer screening program strategy, both regional screening program (OR = 3.43) and organized screening program (OR = 3.12) had a strong and significant fixed effect on SM utilization.

Similarly, EURO-Dr psychological score positively and significantly correlated with SM utilization for all country-level variables. GHE had a higher more significant fixed effect (OR = 1.31) on SM utilization than THE (OR = 1.28). Both regional and organized country programs had a strong, significant effect on SM utilization (OR = 7.12 and 5.92 accordingly).

Likewise, SHr health score positively and significantly correlated with SM utilization for all country-level variables. GHE had a higher and more significant fixed effect (OR = 1.30) on SM utilization than THE (OR = 1.27). Both regional and organized country programs had a strong, significant effect on SM utilization (OR = 6.99 and 5.98 accordingly).

Compared with model 1, there was a reduction of ICC in all models: from 0.10 to 0.07–0.09 for CASP, from 0.19 to 0.14–01.5 for EURO-Dr, and from from 0.19 to 0.14–01.5 for SHr, suggesting that country-level variables explain some of the variation in SM rates between individuals in different countries.

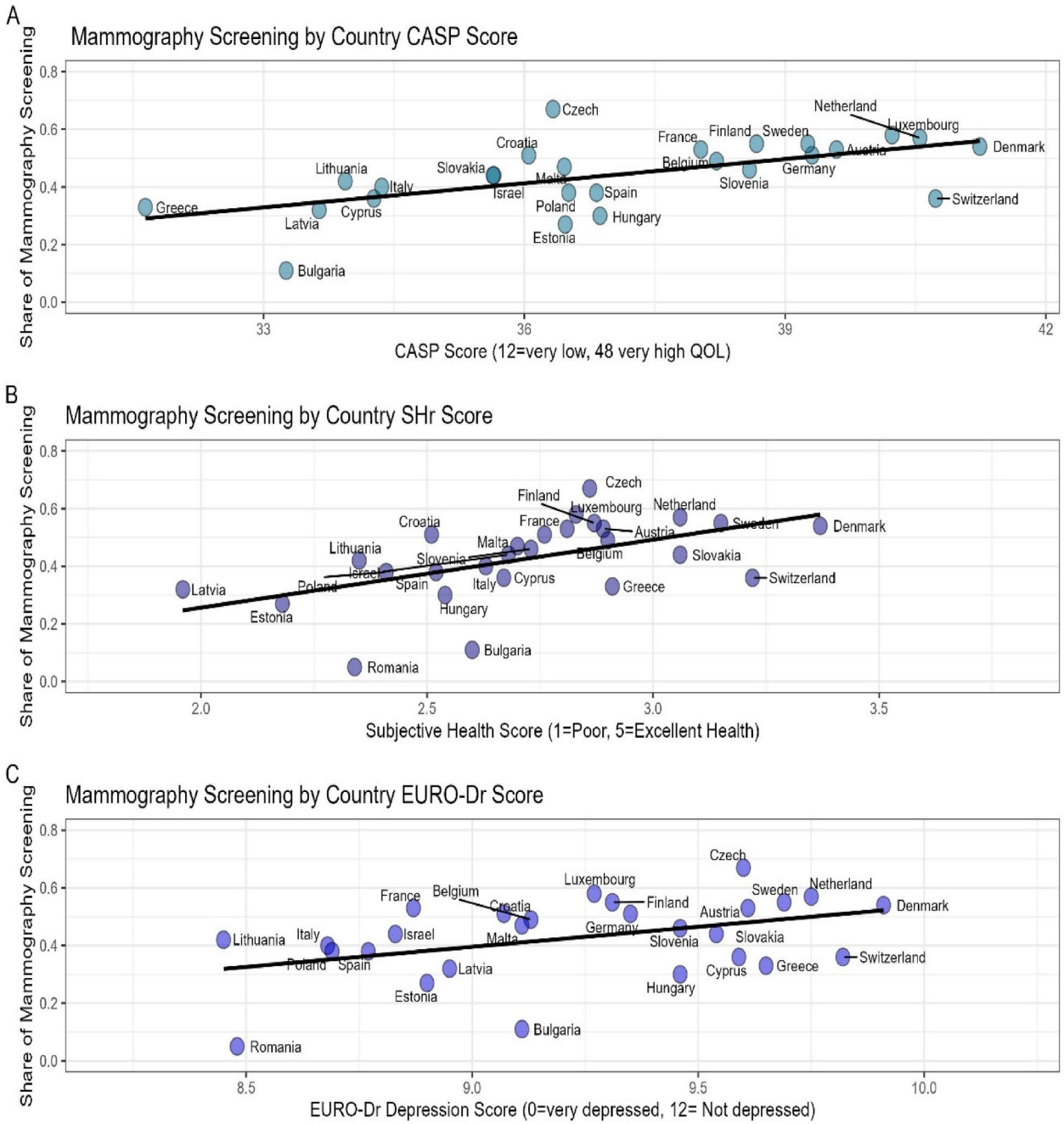

Fig. 2 Mammography screening by country and CASP (**A**), SHr (**B**), and EURO-Dr (**C**)

Model 3 – Cross-level interactions between the individual well-being variables and the country variables – GHE and Country programs

Model-3 focuses on country-level variables representing government policy, GHE and country screening programs. The results for model-3 are illustrated in Figs. 3 and 4 and detailed in supplementary tables 6 and 7.

Figure 3 Panels 1A, 2A and 3A show the predicted probabilities of undergoing SM according to CASP well-being score for three values of GHE: 4% of GDP (low), 6% of GDP (medium), and 9% of GDP (high). Panels 1B, 2B and 3B show the converging lines of predicted probabilities for undergoing SM for different well-being scores by GHE.

Table 2 Model 1 random intercept equations

	CASP QOL score (12–48)	EURO-Dr psychological score (0–12)	SHr subjective health (1–5)
Equation	Odds Ratio	Odds Ratio	Odds Ratio
Intercept	207.7 *** (133.52 – 323.12)	708.4 *** (447.52 – 1121.33)	593.58 *** (378.22–931.55)
Age	0.90 *** (0.89–0.90)	0.90 *** (0.89–0.90)	0.90 *** (0.89–0.90)
Years of Education	1.03 *** (1.02–1.04)	1.04 *** (1.03–1.04)	1.03 *** (1.03–1.04)
Unmet needs	0.89** (0.83–0.96)	0.82*** (0.77–0.88)	0.84*** (0.78–0.89)
Chronic diseases	1.11 *** (1.09 – 1.13)	1.08 *** (1.06 – 1.10)	1.10 *** (1.08 – 1.12)
CASP QOL score	1.04 *** (1.03 – 1.04)		
EURO-Dr psychological score		1.02 * (1.00 – 1.03)	
SHr subjective health score			1.10 *** (1.07 – 1.14)
Random Effect			
τ_{00}	0.37 $_{country}$	0.78 $_{country}$	0.75 $_{country}$
ICC	0.10	0.19	0.19
N	26 $_{countries}$	27 $_{countries}$	27 $_{countries}$
Observations	24433	25706	26478
Marginal R^2 / Conditional R^2	0.241 / 0.319	0.215 / 0.364	0.226 / 0.371
AIC	27715.122	28795.741	29389.870
log-Likelihood	-13823.7	-14364.3	-14660.3

Three random intercept logistic multilevel equations, with the fixed effect of the individual-level characteristics and one source of variation in SM were estimated; τ00, intercept variation. The explanatory variables include the exposure variables and individual-level covariate variables. Romania was excluded from the CASP model, leaving us with 26 countries in this analysis

* $p < 0.05$

** $p < 0.01$

*** $p < 0.001$

Table 3 Model 2 random intercept and country-level covariates

	CASP		EURO-Dr		SHr	
	OR (95%CI)	**ICC**	**OR (95%CI)**	**ICC**	**OR (95%CI)**	**ICC**
THE (% of GDP)	1.16* (1.03–1.30)	0.09	1.28** (1.09–1.49)	0.15	1.27** (1.09–1.48)	0.15
GHE (% of GDP)	1.21*** (1.08–1.36)	0.07	1.31*** (1.11–1.53)	0.14	1.30** (1.11–1.52)	0.14
C**ountry programs—Regional**	3.43** (1.54–7.65)	0.07	7.12*** (2.85–17.79)	0.10	6.99*** (2.85–17.11)	0.10
C**ountry programs—Organized**	3.12*** (1.69–5.72)	0.07	5.92*** (3.06–11.45)	0.10	5.88*** (3.08–11.22)	0.10

Total health expenditure as a proportion of GDP (THE), government health expenditure as a proportion of GDP (GHE) and Country breast cancer screening program strategy (Country programs: Opportunistic (Base), Regional, Organized). For each of the exposure models the left columns show Odds Ratios and 95% Confidence Intervals for each of the regression models. The right columns show the adjusted intraclass correlation (ICC) of each of the regression models. All models were adjusted for individual-level covariates and exposure variables CASP, EURO-Dr, and SHr. For the full models see Supplementary Table 5

* $p < 0.05$

** $p < 0.01$

*** $p < 0.001$

(See figure on next page.)

Fig. 3 Multilevel models with random intercept, country-level covariates, cross-level interactions between individual variables and GHE. A logistic multilevel model for three individual well-being exposures variables: CASP, EURO-Dr and SHr. Government health expenditure as a proportion of GDP (GHE_of_GDP). Panels **A** show the predicted probabilities to perform SM along the well-being variables score for three values of GHE: 4% of GDP (low), 6% of GDP (medium), and 9% of GDP (high). Panels **B** plots show the converging lines of predicted probabilities for performing SM by well-being variable different scores along GHE. For the full models see Supplementary Table 4

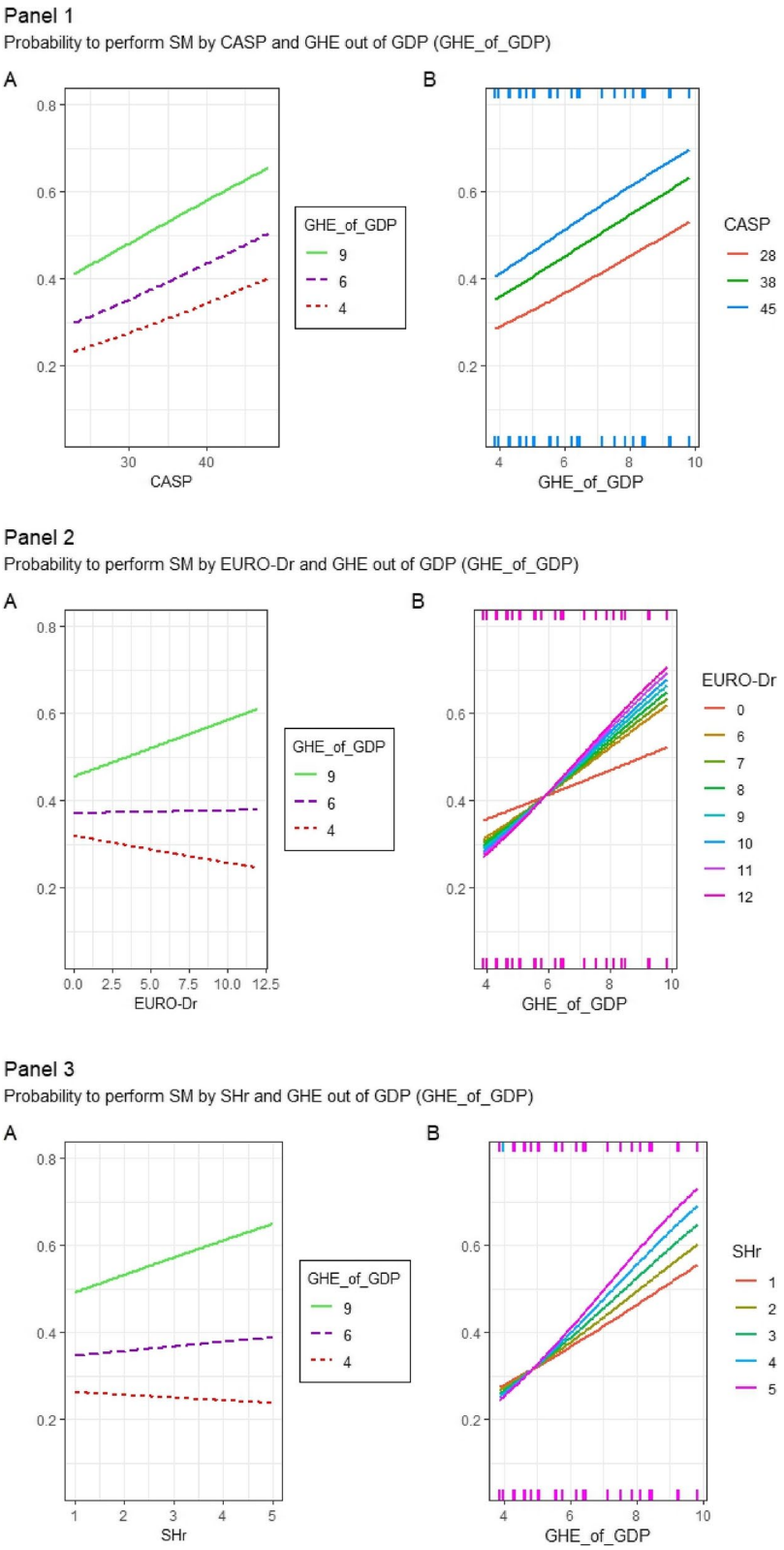

Fig. 3 (See legend on previous page.)

Figure 4 Panels 1A, 2A and 3A show the predicted probabilities of undergoing SM according to well-being score for three values of Country programs: 0 (opportunistic), 1 (regional), and 2 (organized). Panels 1B, 2B and 3B show the converging lines of predicted probabilities for undergoing SM for different Country programs scores.

Cross-level interactions of individual well-being variables and GHE (Fig. 3 and supplementary Table 4)

Both CASP and GHE positively affect the likelihood of undergoing SM. Figure 3-1A and 1B show that SM rates increase with a country's health expenditure level, particularly as the CASP score rises. This trend is consistent across levels of health expenditure, with low-CASP women in high-expenditure countries showing higher SM rates than high-CASP women in low-expenditure countries. The interaction variable between CASP and GHE levels was not significant, indicating that the increase in SM with the increase in CASP scores is not affected by GHE levels. These findings are illustrated also in Fig. 3-1A and 1B, where SM rates follow almost *parallel* lines when plotted against CASP scores and GHE levels.

The interaction between better psychological status (higher EURO-Dr) and GHE (Fig. 3-2A and 2B) revealed notable findings: women in low-expenditure countries have lower SM rates than women in mid- and high-expenditure countries (Fig. 3-2A) as shown in model 2. However, while SM rates increase with EURO-Dr scores in high-expenditure countries, they are not associated in mid-expenditure countries, and in low-expenditure countries, SM rates decrease with EURO-Dr scores (Fig. 3-2B). Nonetheless, SM rates increase with health expenditure overall, albeit with varying intensity depending on the EURO-Dr. Notably, a tipping point is observed at 6% GHE where the trend lines converge.

The interaction between better subjective health status (higher *SHr*) and GHE is demonstrated in Fig. 3-3A and 3B. Figure 3-3A illustrates that SM rates are lower in low-expenditure countries than in mid- and high-expenditure countries. Conversely, SM rates increase with SHr scores in mid- and high-expenditure countries, while in low-expenditure countries SHr scores negatively correlate with SM rates. Similarly, Fig. 3-3B shows that at higher levels of subjective health, SM rates increase with GHE, albeit with varying slopes. Notably, the convergence of trend lines occurs at a government health expenditure of 5%, indicating a tipping point at that level.

Cross-level interactions of the individual well-being variables Country programs (Fig. 4 and supplementary Table 8)

The cross-level interactions of the individual well-being variables and country SM programs (Country programs) are presented in Fig. 4 and resemble the interactions observed with GHE, though the effects for Country programs are smaller. Both CASP and Country programs positively affect the likelihood of undergoing SM. Figures 4-1A and 1B show that SM rates increase with a country's screening program strategy level. This trend is consistent across levels of Country programs (Fig. 4-1A), with low-CASP women in regional (score = 1) and organized (score = 2) program countries showing higher SM rates than high-CASP women in countries with opportunistic strategy (score = 0). The interaction variable between CASP and Country programs levels was not significant, indicating that the increase in CASP scores is not affected by the increase in country's screening program strategy levels. These findings are also illustrated in Fig. 4-1B, where SM rates follow almost *parallel* lines when plotted against CASP scores and Country programs levels.

The interaction variable between psychological status (EURO-Dr) and Country programs (Fig. 4-2A and 2B) was also mixed: women in countries with opportunistic screening programs had lower SM rates than women in countries with regional and organized (Fig. 4-2A), as established in model 2. However, while SM rates increase with EURO-Dr scores in organized program countries, they are not associated in regional program countries, and in opportunistic screening program countries SM rates decrease with EURO-Dr scores. Nonetheless, Fig. 4-2B demonstrates that SM rates increase with Country program overall, albeit with varying intensity depending on the EURO-Dr. Notably, a tipping point is observed at 1.0 (Reginal program) where the trend lines converge.

The interaction between better subjective health (higher SHr) and Country programs is demonstrated in Fig. 4-3A and 3B. Figure 4-3A illustrates that SM rates are lower in opportunistic program countries than in

(See figure on next page.)

Fig. 4 Multilevel models with random intercept, country-level covariates, cross-level interactions between individual variables and Country Programs. A multilevel logistic model for three individual well-being exposures variables: CASP, EURO-Dr and SHr. Country breast cancer screening program strategy (Country programs): Panels **A** plots show the predicted probabilities to perform SM along the well-being variables score for three values of Country-programs: Opportunistic (0), Regional (1), and Organized (2). Panels **B** plots show the converging lines of predicted probabilities for performing SM by well-being variables different scores along Country programs. For full models see Supplementary Table 8

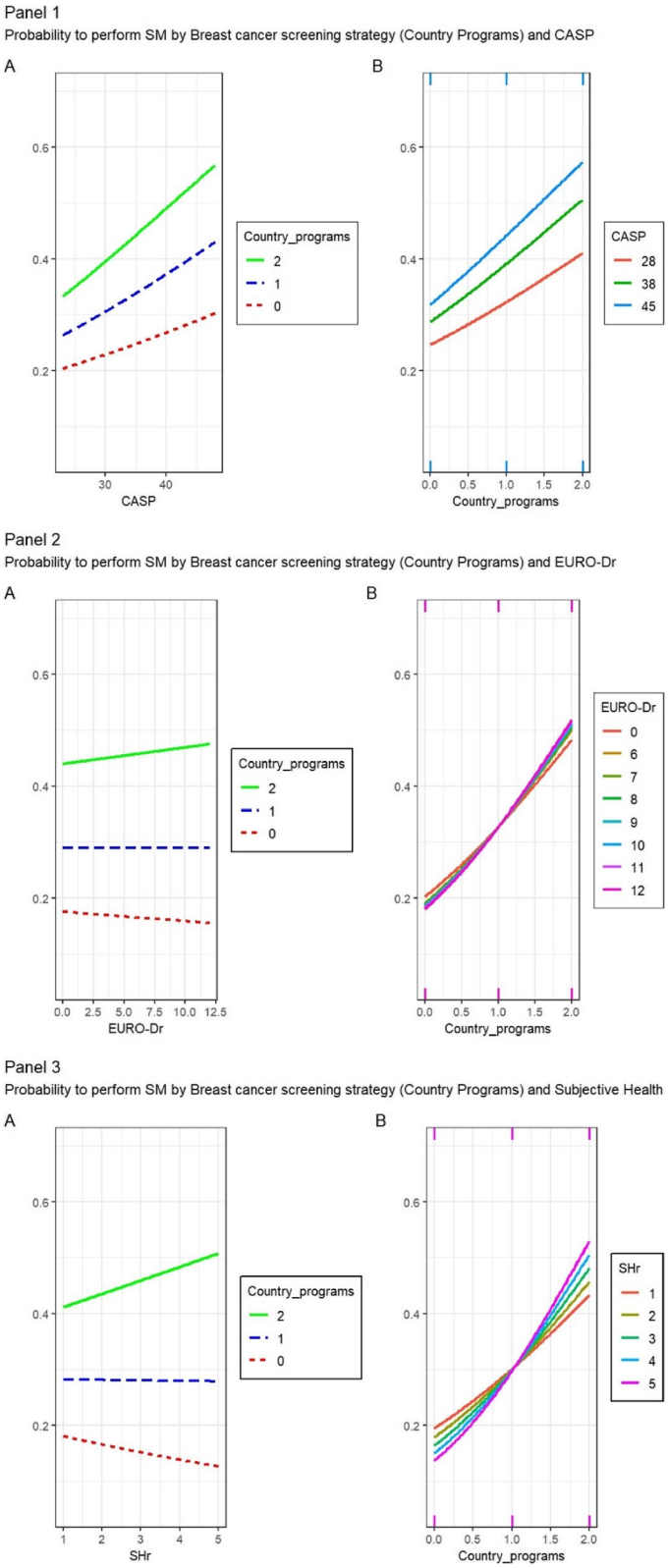

Fig. 4 (See legend on previous page.)

mid- and high-expenditure countries. Conversely, as SM rates increase with SHr scores organized program countries, they are not associated in reginal program countries, and in decreasing in opportunistic program countries. Similarly, Fig. 4-3B shows that at higher levels of subjective health, SM rates increase with Country programs, albeit with varying slopes. Notably, the convergence of trend lines occurs at a Country program's value of 1.0 (regional) indicating a tipping point at that level.

Between groups analysis of GHE and Country programs (Supplementary Table 2)

As GHE trends and Country program trends demonstrated similar behavior in models 2 and 3, we conducted a between-groups ANOVA analysis (Supplementary Table 2). The mean GHE in countries with opportunistic programs was 4.92% of GDP, compared to 7.06% and 6.82% in countries with regional and organized programs, respectively, with the differences being highly significant ($P < 0.001$).

Discussion

The study analyzed individual and country-level variables that influence SM utilization and variation across countries. While prior research focused mainly on individual factors that influence SM rates [9–16], this study looked at individual variables such as quality of life, depression, subjective health, at country-level variable such as health expenditure [12, 18, 20–22] and mammography screening programs [15, 25, 26], and at their interactions. The study employed three models to assess individual, country-level, and interaction effects on SM rates.

As in previous studies [17–19], it was shown that QOL (CASP), subjective psychological status (EURO-Dr), and subjective health status (SHr) have a strong and significant fixed effect on SM performance, indicating that SM is more commonly undergone among women with higher QOL, psychological, and subjective health status. Education and chronic diseases also had a positive fixed effect on SM rates, while age had a negative effect, which is also in line with literature [9–11, 17]. The country-level expenditure variables, namely total health expenditure (THE) and government health expenditure (GHE), demonstrated a significant effect in all the models. GHE had a higher OR than THE, suggesting that public health expenditure has a larger effect on the likelihood of undergoing SM. Moreover, the reduction in intraclass correlation observed across the models indicates that a country's total health expenditure goes a long way in explaining the variation in SM rates. The analysis of country screening program strategies (Country programs) in the study also demonstrated a significant effect on SM utilization. Women in countries without a national screening program were much less likely to undergo SM compared to those in countries with regional or organized national programs, as previously reported [16, 24].

The interaction between individual and country variables in the third model (Figs. 3 and 4) led to particularly interesting results for both the EURO-Dr psychological score and the SHr health score. While SM rates positively correlated with the QOL score at all GHE levels and Country programs scores, and positively correlated with GHE and Country programs scores at all QOL scores [17, 18], this was not the case for the EURO-Dr and the SHr scores. Thus, while SM rates positively correlated with better psychological status and better subjective health in high GHE countries (9% of GDP), they negatively correlated with those variables in low GHE countries (4% of GDP) and had only a weak positive correlation in mid-level GHE countries (6% of GDP). Similar findings were found for Country programs scores, showing positive correlation for organized screening programs, negative correlation for opportunistic screening and only a weak positive correlation for regional programs.

Likewise, SM rates positively correlated with GHE and with Country programs in the case of both EURO-Dr and SHr; however, the correlation coefficient varied significantly between respondents according to their levels of psychological and health status. Thus, while respondents with good health or psychological status were less likely to undergo SM in low GHE countries, those in mid-level and high GHE countries were more likely to have it. The trend lines merged at a GHE level of 5.8% of GDP for EURO-Dr and 5.0% of GDP for SHr. Similarly, the trendlines merged around a score of 1.0 for Country programs, namely regional screening programs.

The study findings indicate that while SM rates among women in countries with generous healthcare expenditure and organized screening programs increase with psychological and physical health, they decrease in less generous countries. This phenomenon has not been previously reported, and there are various possible explanations for its existence. One is the social-ecological cancer care model [3]. According to this model, women are often excluded from policy-making regarding cancer prevention and treatment, leading to opportunistic screening behavior; they tend to suffer more from gender and cancer stigma at the sociocultural level [3, 16]; women may have less access to healthcare services, lack sufficient cancer support and awareness among family and friends, and suffer more from low health literacy, awareness, and financial resources on the individual level [3, 36, 39]. Furthermore, 'breast conflict', a woman's unpleasant feeling towards her breasts, may constitute an individual-level factor influencing SM rates [40]. This effect may vary according to women's

religiosity and social status across countries. Murphy and colleagues analyzed theories of health behavior that can explain SM rates and concluded that the subjective norms of family and friends as well as a doctor's recommendations serve as influential barriers to SM utilization on the interpersonal and health system levels [41]. These factors can vary according to the generosity of a country's healthcare and therefore may explain our findings.

The study's limitations: First, the individual-level data is self-reported, which may have been a source of reporting bias that exaggerated low QOL, psychological status and health status. Nonetheless, the large and diverse population included in SHARE is likely to mitigate this problem. Second, there is a possibility of recall error in the case of retrospective data. However, the quality of the SHARE data is assessed (including consistency) before being released to users [28]. Third, the analysis did not control for the cultural norms and practices of subgroups in the population (i.e., minorities), a factor that future studies should consider. Fourth, it is important to explore country-level variables other than health expenditure and country programs which are linked to an individual's decision to engage in preventative actions. Finally, there are other variables worthy of study, such as genetic endowment, which may potentially impact SM utilization.

Conclusions

This is one of the first studies to use a multiple-country database to compare SM utilization patterns according to the generosity of a country's healthcare. The study concurs with previous research, demonstrating on the individual level that women with better quality of life, psychological well-being, and overall health status are more likely to utilize SM. On the country level, the study shows that higher GHE and organized screening programs have a positive effect as well, as previously reported. Contrastingly, the cross level interaction demonstrated negative correlations of psychological well-being and overall health with SM in low-GHE countries and positive correlations in high-GHE countries, with similar results regarding country screening programs, underscoring disparities that need to be addressed. The incidence of breast cancer is expected to rise as life expectancy increases; therefore, greater attention should be focused on SM practices, especially in lower-GHE countries, and future research should strive to better understand the factors that explain differences in SM utilization between countries.

Abbreviations

CASP	a 12 index of quality-of-life (Control, Autonomy, Self-realization, and Pleasure)
EURO-D	Index of depression
EURO-Dr	Index of depression – reversed (0 is very depressed and 12 is not depressed)
GDP	Gross Domestic Product
GHE	Government health expenditure
QOL	Quality of Life
SH	Subjective Health
SHr	Subjective Health – reversed (1 is poor health and 5 is excellent health)
SHARE	Survey of Health, Ageing and Retirement in Europe
SM	Screening Mammography
THE	Total Health Expenditure

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12939-025-02389-3.

Supplementary Material 1.
Supplementary Material 2.
Supplementary Material 3.
Supplementary Material 4.
Supplementary Material 5.
Supplementary Material 6.
Supplementary Material 7.
Supplementary Material 8.
Supplementary Material 9.
Supplementary Material 10.

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Authors' contributions

B. H.: Conceptualization, Investigation, Visualization, Writing – original draft, Writing – review & editing. S.B.G.: Formal analysis, Investigation, Methodology Software, Validation, Visualization, Writing – original draft, Writing – review & editing.

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Data availability

Data was obtained from the micro-level Pre-Covid Wave 8 (2019–2020) of the Survey of Health, Ageing and Retirement in Europe (SHARE, Release 8.0.0; https://doi.org/10.17617/2.3390284).

Declarations

Ethics approval and consent to participate

Ethics approval was not required for our analysis.

Consent for publication

Consent declaration was not required for our analysis. The study analyzed pre-published data from the SHARE study [28]. The participants of the SHARE study provided their consent back in 2019–2020, therefore there was no need for participant consent for this study.

Competing interests

The authors declare no competing interests.

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References

1. Ferlay J, Ervik M, Lam F, et al. Global cancer observatory: cancer today. 2020. https://gco.iarc.fr/today/home. Accessed 3 Dec 2023.
2. Frick C, Rumgay H, Vignat J, et al. Quantitative estimates of preventable and treatable deaths from 36 cancers worldwide: a population-based study. Lancet Glob Health. 2023;11(11):e1700–12. https://doi.org/10.1016/S2214-109X(23)00406-0.
3. Ginsburg O, Vanderpuye V, Beddoe AM, et al. Women, power, and cancer: a Lancet Commission. Lancet. 2023;402(10417):2113–66. https://doi.org/10.1016/S0140-6736(23)01701-4.
4. OECD. Health at a Glance 2019 OECD indicators. 2019. https://doi.org/10.1787/4dd50c09-en.
5. Denny L, de Sanjose S, Mutebi M, et al. Interventions to close the divide for women with breast and cervical cancer between low-income and middle-income countries and high-income countries. Lancet. 2017;389(10071):861–70. https://doi.org/10.1016/S0140-6736(16)31795-0.
6. Polack FP, Thomas SJ, Kitchin N, et al. Recommendation: breast cancer: screening | United States preventive services taskforce. N Engl J Med. 2016;383(27):2603–15. https://doi.org/10.1056/NEJMOA2034577.
7. Nicholson WK, Silverstein M, Wong JB, et al. Screening for breast cancer: US preventive services task force recommendation statement. JAMA. 2024;331(22):1918–30. https://doi.org/10.1001/JAMA.2024.5534.
8. European Commission. Screening ages and frequencies | Cancer screening, diagnosis and care. 2022. https://healthcare-quality.jrc.ec.europa.eu/ecibc/european-breast-cancer-guidelines/screening-ages-and-frequencies#recs-group-40-44. Accessed 15 June 2023.
9. Salama BMM. Factors affecting mammography screening utilization among educated women in Al Beheira Governorate, Egypt. Indian J Community Med. 2020;45(4):522. https://doi.org/10.4103/IJCM.IJCM_41_20.
10. Sarma EA. Barriers to screening mammography. Health Psychol Rev. 2015;9(1):42–62. https://doi.org/10.1080/17437199.2013.766831/SUPPL_FILE/RHPR_A_766831_SM7997.PDF.
11. Orji CC, Kanu C, Adelodun AI, Brown CM. Factors that influence mammography use for breast cancer screening among African American women. J Natl Med Assoc. 2020;112(6):578–92. https://doi.org/10.1016/J.JNMA.2020.05.004.
12. McAlearney AS, Reeves KW, Tatum C, Paskett ED. Perceptions of insurance coverage for screening mammography among women in need of screening. Cancer. 2005;103(12):2473–80. https://doi.org/10.1002/CNCR.21068.
13. Nnaji CA, Ezenwankwo EF, Kuodi P, Walter FM, Moodley J. Timeliness of diagnosis of breast and cervical cancers and associated factors in low-income and middle-income countries: a scoping review. BMJ Open. 2022;12(2):e057685. https://doi.org/10.1136/BMJOPEN-2021-057685.
14. Palència L, Espelt A, Rodríguez-Sanz M, et al. Socio-economic inequalities in breast and cervical cancer screening practices in Europe: influence of the type of screening program. Int J Epidemiol. 2010;39(3):757–65. https://doi.org/10.1093/IJE/DYQ003.
15. Willems B, Bracke P. The education gradient in cancer screening participation: a consistent phenomenon across Europe? Int J Public Health. 2018;63(1):93–103. https://doi.org/10.1007/S00038-017-1045-7.
16. Willems B, Cullati S, De PV, Jolidon V, Burton-Jeangros C, Bracke P. Cancer screening participation and gender stratification in Europe. J Health Soc Behav. 2020;61(3):377–95. https://doi.org/10.1177/0022146520938708.
17 Wuebker A. Who gets a mammogram amongst European women aged 50–69 years? Health Econ Rev. 2012;2:6. https://doi.org/10.1186/2191-1991-2-6.
18. Hafslund B, Espehaug B, Nortvedt MW. Health-related quality of life, anxiety and depression related to mammography screening in Norway. J Clin Nurs. 2012;21(21–22):3223–34. https://doi.org/10.1111/J.1365-2702.2012.04244.X.
19. Bui KT, Liang R, Kiely BE, Brown C, Dhillon HM, Blinman P. Scanxiety: a scoping review about scan-associated anxiety. BMJ Open. 2021;11(5):e043215. https://doi.org/10.1136/BMJOPEN-2020-043215.
20. Miles RC, Flores EJ, Carlos RC, et al. Impact of health care-associated cost concerns on mammography utilization: cross-sectional survey results from the national health interview survey. J Am Coll Radiol. 2022;19(10):1081–7. https://doi.org/10.1016/J.JACR.2022.06.001.
21. Fayanju OM, Kraenzle S, Drake BF, Oka M, Goodman MS. Perceived barriers to mammography among underserved women in a Breast Health Center outreach program. Am J Surg. 2014;208(3):425–34. https://doi.org/10.1016/J.AMJSURG.2014.03.005.
22. Tran L, Chetlen AL, Leslie DL, Segel JE. Effect of out-of-pocket costs on subsequent mammography screening. J Am Coll Radiol. 2022;19(1):24–34. https://doi.org/10.1016/J.JACR.2021.09.028.
23. Sabatino SA, Thompson TD, Guy GP, De Moor JS, Tangka FK. Mammography use among medicare beneficiaries after elimination of cost sharing. Med Care. 2016;54(4):394. https://doi.org/10.1097/MLR.0000000000000495.
24. Jolidon V, Bracke P, Burton-Jeangros C. Macro-contextual determinants of cancer screening participation and inequalities: a multilevel analysis of 29 European countries. SSM Popul Health. 2021;15:100830. https://doi.org/10.1016/J.SSMPH.2021.100830.
25. Peintinger F. National breast screening programs across Europe. Breast Care. 2019;14(6):354. https://doi.org/10.1159/000503715.
26. Altobelli E, Rapacchietta L, Angeletti PM, Barbante L, Profeta FV, Fagnano R. Breast cancer screening programmes across the WHO European Region: differences among countries based on national income level. Int J Environ Res Public Health. 2017;14(4):452. https://doi.org/10.3390/IJERPH14040452.
27 Deandrea S, Molina-Barceló A, Uluturk A, et al. Presence, characteristics and equity of access to breast cancer screening programmes in 27 European countries in 2010 and 2014. Results from an international survey. Prev Med (Baltim). 2016;91:250–63. https://doi.org/10.1016/J.YPMED.2016.08.021.
28. Bergmann M, Kneip T, De Luca G, Scherpenzeel A. Survey participation in the Eighth Wave of the Survey of Health, Ageing and Retirement in Europe (SHARE) About the SHARE Working Paper Series. SHARE working paper series. 2022. https://doi.org/10.17617/2.3390284.
29. OECD. Health: health expenditure and financing. OECDs.Stat; 2022. https://stats.oecd.org/index.aspx?queryid=61433#. Accessed 20 Jul 2023.
30. Ponti A, Anttila A, Ronco G, Senore C. Cancer screening in report on the implementation of the council recommendation on cancer screening. https://health.ec.europa.eu/document/download/911ecf9b-0ae2-4879-93e6-b750420e9dc0_en. Accessed 21 Aug 2024.
31. Tur-Sinai A, Shahrabani S. Determinants of women's decision to undergo early mammography: a survey study. Nurs Health Sci. 2020;22(4):1000–9. https://doi.org/10.1111/NHS.12759.
32. Bulliard JL, Braendle K, Zwahlen M. Monitoring breast cancer screening 2010–2018 in Switzerland. 2021.
33. Mehrbrodt T, Gruber S, Wagner M. Scales and multi-item indicators in the survey of health, ageing and retirement in Europe. 2019.
34. Prince MJ, Reischies F, Beekman ATF, et al. Development of the EURO-D scale–a European, Union initiative to compare symptoms of depression in 14 European centres. Br J Psychiatry. 1999;174:330–8. https://doi.org/10.1192/BJP.174.4.330.
35. Finch WH, Bolin JE. Multilevel modeling using R. Chapman & Hall/CRC Press; 2024. https://www.routledge.com/Multilevel-Modeling-Using-R/Finch-Bolin/p/book/9781032363943. Accessed 23 Aug 2024.
36. Bliese P. Multilevel modeling in R (2.7) A Brief Introduction to R, the multilevel package and the nlme package. 2022.
37. Bryan ML, Jenkins SP. Multilevel modelling of country effects: a cautionary tale. Eur Sociol Rev. 2016;32(1):3–22. https://doi.org/10.1093/ESR/JCV059.
38. Finch WH, Bolin JE, Kelley K. Multilevel Modeling Using R. 2nd ed. Chapman and Hall/CRC; 2019. https://doi.org/10.1201/9781351062268.
39. Bronfenbrenner U. Ecology of the family as a context for human development. Res Perspect Dev Psychol. 1986;22(6):723–42. https://doi.org/10.1037/0012-1649.22.6.723.
40. Shirzadi S, Asghari-Jafarabadi M, Kouzekanani K, Hasankhani H, Allahverdipour H. Assessing the mediating role of breast conflict on cognitive factors associated with adopting mammography. Women Health. 2019;59(5):510–23. https://doi.org/10.1080/03630242.2018.1500414.
41. Murphy CC, Vernon SW, Diamond PM, Tiro JA. Competitive testing of health behavior theories: how do benefits, barriers, subjective norm, and intention influence mammography behavior? Ann Behav Med. 2014;47(1):120–9. https://doi.org/10.1007/S12160-013-9528-0.

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