Research article

The association of demographic and socioeconomic variables with cancer screening participation: A national cross-sectional study of three cancer screening programs in Denmark

Anne Dorte Lerche Helgestad [a,b,*], Berit Andersen [a,b], Sisse Helle Njor [b,c], Mette Bach Larsen [a,b,d]

[a] *University Research Clinic for Cancer Screening, Department of Public Health Programmes, Randers Regional Hospital, Skovlyvej 15, 8930, Randers NO, Denmark*
[b] *Department of Clinical Medicine, Aarhus University, Palle Juul-Jensens Blvd. 82, 8200, Aarhus N, Denmark*
[c] *Department of Data, Innovation and Research, Lillebaelt Hospital, Vejle, Beriderbakken 4, 7100, Vejle, Denmark*
[d] *Research Unit, Horsens Regional Hospital, Sundvej 30, 8700, Horsens, Denmark*

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ABSTRACT

Objective: To analyze the demographic and socioeconomic determinants of non-participation in cervical, colorectal and breast cancer screening programs in Denmark.

Study design and setting: We conducted a cross-sectional study involving all women aged 53–65 years residing in Denmark on March 31, 2018, utilizing comprehensive individual data from population registries. Logistic regression models were employed to assess associations between demographic and socioeconomic factors and non-participation compared with participating in one, two, and three cancer screening programs, presenting odds ratios (ORs) with 95 % confidence intervals (CIs). Both unadjusted and adjusted models were applied for each level of screening participation.

Results: Significant associations with non-participation in the three cancer screening programs were observed across all demographic and socioeconomic covariates considered. Women with low incomes demonstrated the highest likelihood of non-participation (none vs. three programs attended, OR: 2.95, 95 % CI: 2.82–3.08). Similarly, increased odds of non-participation were noted among immigrants (Western immigrants: OR: 2.08, 95 % CI: 1.96–2.21; non-Western immigrants OR 1.26 95 % CI: 1.20–1.32), women living alone (OR: 2.08, 95 % CI: 2.02–2.14), women outside the labor force (OR: 1.92, 95 % CI: 1.86–1.99), and women with lower educational levels (OR: 1.44, 95 % CI: 1.39–1.50) in the model comparing non-participation to participating in three screening programs. A progressive intensification of the association with non-participation was noted with each incremental increase in screening participation (from one to two to three programs).

Conclusions: Demographic and socioeconomic variables are significantly associated with non-participation in all three Danish cancer screening programs, particularly affecting women from vulnerable demographic and socioeconomic backgrounds. Future research should prioritize strategies to enhance participation within this subgroup, aiming to alleviate social inequities in cancer screening.

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* Corresponding author. University Research Clinic for Cancer Screening, Randers Regional Hospital, Skovlyvej 15, 8930 Randers NO, Denmark.
E-mail addresses: annesper@rm.dk (A.D.L. Helgestad), berand@rm.dk (B. Andersen), sisse.helle.njor@rsyd.dk (S.H. Njor), metbacla@rm.dk (M.B. Larsen).

1. Introduction

Cancer is a leading cause of death with almost two million deaths in 2020 in Europe [1]. In the same year, the incidence of cancer in Europe was estimated at four million new cases with breast cancer accounting for 530,000 cases and colorectal cancer for 520,000 cases, making them the most common cancers in Europe [2]. Internationally, cancer is characterized by significant disparities socioeconomic morbidity and mortality [3–5].

Since cancer screening contributes to prevention and early detection, population-based screening for breast, colorectal, and cervical cancer has been recommended by the European Union Council since 2003 [6]. For a screening program to be effective, it is essential to have a high participation rate [7,8]. While some women opt for all three screening offers, others choose to participate in only one or two programs, and some do not participate at all [9,10]. Two European studies have shown participation rates concurrent in all three programs ranging from 35 % to 54 %, with 10 %–12.6 % of individuals not participating at all [11,12]. Similarly, Danish participation rates have been found to be 55 % for all screening programs, and with 7 % not participating in any [10]. Non-participation poses a challenge for healthcare planners. Several studies have sought to identify factors predicting an increased risk of non-participation in cancer screening programs [9,13–15], and demographic and socioeconomic factors have been identified as some of the factors associated with non-participation in cancer screening and, consequently, causing disparity in cancer screening [13, 16–20].

However, it has yet to be explored if women not participating in any cancer screening programs constitute a more vulnerable group with shared demographic and socioeconomic characteristics. In-debt knowledge of this subpopulation could contribute to a more tailored screening offer. Subsequently, this could have the potential to reduce social inequity in cancer screening and, furthermore, reduce cancer morbidity and mortality for this population.

In this national register-based cross-sectional study, we identified any shared demographic and socioeconomic profiles of non-participants in both breast, cervical and colorectal cancer screening programs in Denmark as compared with those participating in one, two, or three cancer screening programs.

2. Materials and methods

2.1. Setting

Denmark has implemented three organized cancer screening programs; cervical cancer screening, breast cancer screening, and most recently colorectal cancer screening since 2014.

Women aged 23–64 years are invited to screening for cervical cancer, with the option to schedule an appointment at a general practitioner. The screening tests for cervical cancer alternate between cytology and HPV testing every three to five years based on the woman's age. If a cervical sample is not registered after an invitation, up to two reminders are sent after three and six months, respectively.

Women aged 50–69 years receive a biennial invitation for a pre-booked mammography. In the event of non-attendance, one reminder is sent.

Colorectal cancer screening is offered biennially using a Fecal Immunochemical Test (FIT), which is mailed to all residents aged 50–74 years along with a prepaid return envelope. A reminder is sent if a fecal sample is not registered within 45 days after the invitation.

All three programs operate under a call-recall invitation strategy, and all residents are invited when in the screening-eligible age based on population registers [21]. The programs are administered by the five Danish regions, who ensure timely invitations and reminders for residents overdue for screening.

The Danish healthcare system is mainly financed through taxes, and this includes cancer screening, subsequent diagnostics and potential treatment. Residents receive invitations, reminders and test results through secure, digital mail, which all residents are obliged to have (exemptions are provided) [21].

2.2. Design and study population

The study was a national cross-sectional study based on extensive register data on the Danish population. As previously reported [10], the study population consisted of 468,507 women aged 53–64 years living in Denmark on March 31, 2018 and with continuous residency in Denmark since April 1, 2012. Women with a prior diagnosis of cervical, breast, or colorectal cancer, or those who had undergone a hysterectomy, were excluded, as they were not considered eligible in all three screening programs. Women were considered participants in each screening program if they had undergone at least one mammography, cervical sample, or FIT between April 1, 2012 and March 31, 2018. Based on this, the study population was categorized as participating in none, one, two, or all three cancer screening programs.

2.3. Data sources

All Danish residents receive a unique civil registration (CPR) number at birth or upon immigration, which can be used as an individual-level data linkage [21]. The population was identified using the Civil Registration System, which contains migration and

vital status records for the entire Danish population since 1968 [22].

As described elsewhere [10], information on participation in breast cancer screening was obtained from the Danish Breast Cancer Screening Database. Participation data for cervical cancer screening was obtained from the Danish Pathology Registry, and participation data for colorectal cancer screening was obtained from the Danish Colorectal Cancer Screening Database.

Information on hysterectomy was collected from the Danish National Patient Registry, and information on cancer cases was retrieved from the Danish Pathology Registry [23].

Demographic and socioeconomic data were obtained from Statistics Denmark [24]. Ethnicity was categorized based on Statistics Denmark's classification by country of origin into three groups: Danish, Western (including countries within the European Union, Andorra, Australia, Canada, Iceland, Liechtenstein, Monaco, New Zealand, Norway, San Marino, Switzerland and the USA), and non-Western (others). Marital status was categorized as either living alone or cohabitating (including being married, living in a registered partnership, and cohabitating). Occupation was classified into three groups: part of the labor force, outside the labor force (including unemployment, receiving benefits, welfare recipients, early retirement pensioners, and those with no category), and retired (due to age). Household income was categorized according to the Organization for Economic Co-operation and Development (OECD)-modified equivalence scale, based on tertiles and rounded off to the nearest 1000 Euros. Highest educational attainment was classified according to the United Nations Educational, Scientific and Cultural Organization's (UNESCO) classifications as low ($\leq$10 years), middle (11–15 years), or high (>15 years). All demographic and socioeconomic data were collected at an individual level.

2.4. Statistical analysis

Demographic and socioeconomic characteristics were summarized using descriptive statistics (numbers and proportions) and differences were tested using Pearson's chi-squared test. Odds ratios (ORs) with 95 % confidence intervals (CIs) were calculated using logistic regression to estimate the associations between demographic and socioeconomic factors and non-participation, comparing non-participation with participation in one, two, or three programs. Initially, an unadjusted analysis was performed for each demographic and socioeconomic factor. Subsequently, an adjusted analysis was conducted that included all the independent variables.

As sensitivity analyses, stratified analyses were performed for each independent variable to assess the significance of potential interactions in the adjusted model, which compared non-participation with participation in the three programs.

Missing data were not considered in the analysis due to their limited presence within the dataset.

All tests were two-sided and P-values <0.05 were considered statistically significant. Statistical analyses were conducted using STATA V.17.

2.5. Ethics approval

The study was listed in the record of processing activities for research projects in the Central Denmark Region (R. No.: 1-16-02-217-21). According to Danish Legislation, notification of register-based research project to the research committee is not required. Hence, this study may be conducted without an approval from ethics committees.
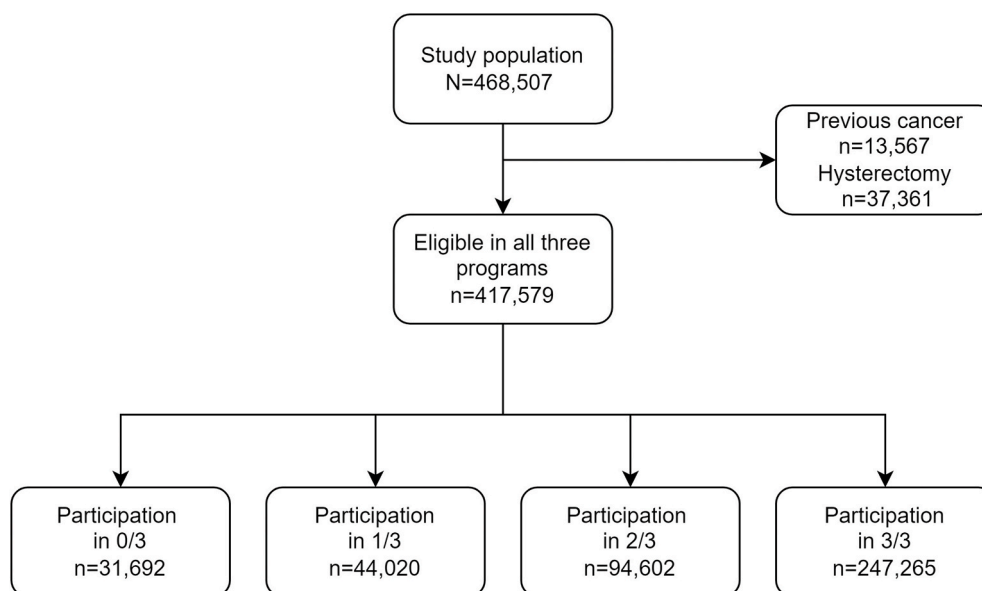

Fig. 1. Flowchart of the study population. *Previous cancer: cervical cancer, breast cancer, and colorectal cancer.

3. Results

A flowchart of the population is presented in Fig. 1. Out of the initial 468,507 women included, 13,567 were excluded due to a history of previous breast, cervical, or colorectal cancer, and 37,361 women were excluded due to hysterectomy. Among the 417,579 women eligible for all three screening programs, 59.2 % (n = 247,265) had participated in all three, 22.7 % (n = 94,602) in two, 10.5 % (n = 44,020) in one, and 7.6 % (n = 31,692) in none of the cancer screening programs.

Characteristics of the included population are detailed in Table 1. Statistically significant differences were observed for all demographic and socioeconomic covariates. Missing data were more frequent in the group of non-participants, while no socioeconomic variables were missing for those participating in three programs, except for educational data.

The unadjusted and the adjusted ORs for non-participation, compared with participating in one, two, or three programs, are presented in Table 2. Following adjustment, the OR for non-participation increased with age across each level of participation.

Immigrants were more likely not to participate in cancer screenings, with a progressively increasing likelihood of non-participation across higher levels of participation. The ORs for Western immigrants were 1.44 (0 vs. 1, 95 % CI:1.34–1.55), 1.83 (0 vs. 2, 95 % CI: 1.71–1.96), and 2.08 (0 vs. 3, 95 % CI: 1.96–2.21), compared with ethnic Danes. For non-Western immigrants, the ORs for non-participation were 1.07 (0 vs. 1, 95 % CI: 1.01–1.13), 1.10 (0 vs. 2, 95 % CI: 1.04–1.16), and 1.26 (0 vs. 3, 95 % CI: 1.20–1.32).

Living alone, compared with cohabitating, was associated with increased odds of non-participation across all levels of participation, progressing from attending one to three programs (0 vs. 1, OR: 1.25, 95 % CI: 1.21–1.29; 0 vs. 2, OR: 1.58, 95 % CI: 1.53–1.62; 0 vs. 3, OR: 2.08, 95 % CI: 2.02–2.14). In terms of occupation, being outside the labor force was negatively associated with screening participation. The ORs for non-participation were as follows: 1.24 (0 vs. 1, 95 % CI: 1.19–1.29), 1.48 (0 vs. 2, 95 % CI: 1.43–1.53), and 1.92 (0 vs. 3, 95 % CI: 1.86–1.99).

Women with less than 11 years of education were more likely to be non-participants, compared to those who had more than 15 years of education. The ORs for non-participation were: 1.12 (0 vs. 1, 95 % CI: 1.08–1.17), 1.32 (0 vs. 2, 95 % CI: 1.27–1.389, and 1.44 (0 vs. 3, 95 % CI: 1.39–1.50). Women with 11–15 years of education exhibited an increased likelihood of participating, with an OR of

Table 1
Demographic and socioeconomic characteristics of the study population by participation in cancer screening programs.

	0/3 n = 31,692		1/3 n = 44,020		2/3 n = 94,602		3/3 n = 247,265		P-value[a]
	n	%	n	%	n	%	n	%	
Age (years)									
Median in years		59.7 y		58.9 y		58.7 y		59.1 y	<0.01
53–55	6909	21.8 %	11,812	26.8 %	26,743	28.3 %	64,473	26.1 %	
56–60	11,137	35.1 %	16,942	38.5 %	36,941	39.1 %	94,539	38.2 %	
61–65	13,646	43.1 %	15,266	34.7 %	30,918	32.7 %	88,253	35.7 %	
Ethnicity									
Danish	25,622	80.9 %	38,516	87.5 %	85,501	90.4 %	230,687	93.3 %	<0.01
Western immigrants	1654	5.2 %	1706	3.9 %	2839	3.0 %	6114	2.5 %	
Non-Western immigrants	2861	9.0 %	3551	8.1 %	>6255[b]	6.6 %	10,464	4.2 %	
Missing	1555	4.9 %	247	0.6 %	<5[b]	0 %	0	0 %	
Marital status									
Cohabitating[c]	13,952	44.0 %	24,529	55.7 %	61,740	65.3 %	184,367	74.6 %	<0.01
Living alone	16,185	51.1 %	19,244	43.7 %	>32,855[b]	34.7 %	62,898	25.4 %	
Missing	1555	4.9 %	247	0.6 %	<5[b]	0 %	0	0 %	
Income[d]									
High tertile	4241	13.4 %	9481	21.5 %	28,458	30.1 %	94,232	38.1 %	<0.01
Middle tertile	7614	24.0 %	13,305	30.2 %	31,347	33.1 %	88,171	35.7 %	
Low tertile	18,282	57.7 %	20,987	47.7 %	>34,790[b]	36.8 %	64,862	26.2 %	
Missing	1555	4.9 %	247	0.6 %	<5[b]	0 %	0	0 %	
Occupation									
Part of the labor force	13,295	42.0 %	23,923	54.4 %	59,592	63.0 %	169,509	68.6 %	<0.01
Outside the labor force[e]	13,611	43.0 %	14,973	34.0 %	24,271	25.7 %	42,348	17.1 %	
Retired	4010	12.7 %	4972	11.3 %	10,739	11.4 %	35,408	14.3 %	
Missing	776	2.5 %	152	0.4 %	0	0 %	0	0 %	
Education[f]									
High (>15 years)	7392	23.3 %	11,667	26.5 %	28,932	30.6 %	80,114	32.4 %	<0.01
Middle (11–15 years)	11,552	36.5 %	17,866	40.6 %	40,842	43.2 %	113,737	46.0 %	
Low (≤10 years)	11,075	35.0 %	13,060	29.7 %	23,069	24.4 %	50,921	20.6 %	
Missing	1673	5.3 %	1427	3.2 %	1759	1.9 %	2493	1.0 %	

Abbreviations: y, years.

[a] Tested by Pearson chi-squared test.

[b] Exact numbers are not given in pursuance of Danish data protection legislation.

[c] Cohabitating includes: being married, living in a registered partnership, and cohabitating.

[d] Household income according to the Organization for Economic Co-operation and Development (OECD)-modified equivalence scale. Based on tertiles and rounded off to the nearest 1000 Euros. High tertile: >49.000 Euros, middle tertile: 33.000–49.000 Euros, low tertile: <33.000 Euros.

[e] Outside the labor force include: unemployment, receiving benefits, welfare recipients, early retirement pensioners, and those with no category.

[f] Education according to the classification of United Nations Educational, Scientific and Cultural Organization.

Table 2
Unadjusted and adjusted odds ratios with 95 % confidence intervals for association between demographic and socioeconomic variables and non-participation versus participation in one, two, or three cancer screening programs.

	0 vs. 1 screenings attended		0 vs. 2 screenings attended		0 vs. 3 screenings attended	
	Crude OR (95 % CI)	Adjusted OR (95 % CI)	Crude OR (95 % CI)	Adjusted OR (95 % CI)	Crude OR (95 % CI)	Adjusted OR (95 % CI)
Age (years)						
53–55	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)
56–60	1.12 (1.08–1.17)	1.10 (1.06–1.14)	1.17 (1.13–1.21)	1.11 (1.07–1.15)	1.10 (1.07–1.13)	1.03 (0.99–1.06)
61–65	1.53 (1.47–1.59)	1.33 (1.27–1.39)	1.71 (1.65–1.77)	1.40 (1.34–1.45)	1.44 (1.40–1.49)	1.19 (1.15–1.23)
Ethnicity						
Danish	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)
Western immigrants	1.46 (1.36–1.56)	1.44 (1.34–1.55)	1.94 (1.83–2.07)	1.83 (1.71–1.96)	2.44 (2.30–2.58)	2.08 (1.96–2.21)
Non-Western immigrants	1.21 (1.15–1.28)	1.07 (1.01–1.13)	1.53 (1.46–1.60)	1.10 (1.04–1.16)	2.46 (2.36–2.57)	1.26 (1.20–1.32)
Marital status						
Cohabiting[a]	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)
Living alone	1.48 (1.44–1.52)	1.25 (1.21–1.29)	2.18 (2.12–2.24)	1.58 (1.53–1.62)	3.40 (3.32–3.48)	2.08 (2.02–2.14)
Income[b]						
High tertile	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)
Middle tertile	1.28 (1.22–1.34)	1.16 (1.11–1.22)	1.63 (1.56–1.70)	1.35 (1.29–1.41)	1.92 (1.85–1.99)	1.49 (1.43–1.55)
Low tertile	1.95 (1.87–2.03)	1.46 (1.39–1.54)	3.53 (3.40–3.66)	2.03 (1.94–2.13)	6.26 (6.05–6.48)	2.95 (2.82–3.08)
Occupation						
Part of the labor force	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)
Outside the labor force[c]	1.64 (1.59–1.69)	1.24 (1.19–1.29)	2.51 (2.44–2.59)	1.48 (1.43–1.53)	4.10 (3.99–4.21)	1.92 (1.86–1.99)
Retired	1.45 (1.39–1.52)	1.03 (0.97–1.09)	1.67 (1.61–1.74)	0.99 (0.94–1.04)	1.44 (1.39–1.50)	0.81 (0.77–0.84)
Education[d]						
High (>15 years)	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)	1 (ref)
Middle (11–15 years)	1.02 (0.98–1.06)	0.97 (0.93–1.01)	1.11 (1.07–1.14)	0.99 (0.95–1.02)	1.10 (1.07–1.13)	0.92 (0.89–0.96)
Low (≤10 years)	1.34 (1.29–1.39)	1.12 (1.08–1.17)	1.88 (1.82–1.94)	1.32 (1.27–1.38)	2.36 (2.28–2.43)	1.44 (1.39–1.50)

Abbreviations: OR, odds ratio; CI, confidence intervals; ref, reference.
The adjusted model included age, ethnicity, marital status, income, occupation, and education.
[a] Cohabiting includes: being married, living in a registered partnership, and cohabiting.
[b] Household income according to the Organization for Economic Co-operation and Development (OECD)-modified equivalence scale. Based on tertiles and rounded off to the nearest 1000 Euros. High tertile: >49.000 Euros, middle tertile: 33.000–49.000 Euros, low tertile: <33.000 Euros.
[c] Outside the labor force include: unemployment, receiving benefits, welfare recipients, early retirement pensioners, and those with no categor
[d] Education according to the classification of United Nations Educational, Scientific and Cultural Organization (UNESCO).

0.92 (0 vs. 3, 95 % CI: 0.89–0.96). The ORs comparing participation in one and two screenings to none were non-significant for this education group: 0.97 (0 vs. 1, 95 % CI: 0.93–1.01) and 0.99 (0 vs. 2, 95 % CI: 0.95–1.02). Income was inversely associated with non-participation; lower income levels were linked to increased odds of non-participation across all levels of screening attendance. Additionally, these odds increased when comparing higher numbers of screenings attended to non-participation (0 vs. 1, middle tertile OR: 1.16, 95 % CI: 1.11–1.22, low tertile OR: 1.46, 95 % CI: 1.39–1.54; 0 vs. 2, middle tertile OR 1.35, 95 % CI: 1.29–1.41, low tertile OR: 2.03, 95 % CI: 1.94–2.13; 0 vs. 3, middle tertile OR: 1.49, 95 % CI: 1.43–1.55, low tertile OR: 2.95, 95 % CI: 2.82–3.08).

Sensitivity analyses stratified by age group, ethnicity, marital status, income, occupation, and education did not alter the observed patterns in the ORs for complete non-participation when comparing none to three screenings attended (Supplemental material).

4. Discussion

4.1. Main findings

In this nationwide register-based cross-sectional study, differences in the odds of non-participation were observed across all demographic and socioeconomic subgroups. Notably, immigrants, women living alone, women with lower disposable incomes, those outside the labor force, and less educated women exhibited a progressive increase in the odds of non-participation as the number of screenings attended increased. These findings indicate growing socioeconomic disparities among those who do not engage in cancer screenings.

4.2. Strengths and limitations

An important strength of the study is our access to nationwide data, facilitating the linkage of the CPR number with high-validity and high-quality registry data [21]. The use of national registries enables the conduction of large-scale studies that integrate individual data, eliminating reliance on self-reported information and minimizing missing data. Consequently, the potential for selection and information bias is reduced. However, data on sociodemographic variables are updated only annually. For our analysis, we utilized

data spanning from 2016 to 2018, favoring the most recently available information for each individual. Nevertheless, sociodemographic factors such as marital status and income can be dynamic, potentially leading to misclassification.

Interactions among the sociodemographic variables may influence the accuracy of the estimates. However, it is important to highlight that the primary aim was to analyze the social component among women who did not participate in all three screening programs, rather than the effect of each variable independently. Further, sensitivity analyses demonstrated only minor changes in the patterns of the ORs for non-participation, suggesting the adjusted model was robust.

We cannot rule out potential implications from residual confounding, given that factors beyond demographic and socioeconomic variables have demonstrated associations with cancer screening participation. This study lacked access to data on lifestyle factors, healthcare utilization (e.g., severe comorbidities and medication use), level of health literacy, and psychological factors. These variables could contribute to the observed disparities in participation among different demographic and socioeconomic groups [25–29].

4.3. Comparison with other studies

Existing studies have primarily focused on each cancer screening program independently and its association with demographic and socioeconomic factors. One exception is a recent Dutch study [12] that closely resembles the population and health system in Denmark. Variables included in the Dutch study are the population density of the place of residence and the median annual household income of the postal code area of residence. Our study contributes to the existing literature by incorporating multiple individual-level covariates and by analyzing variations across different levels of participation. This approach allows for a comprehensive depiction of demographic and socioeconomic distinctions between non-participants and those with progressively higher levels of screening participation.

In line with both national and international studies from each of the separate programs, non-native women exhibited higher odds of non-participation compared to native women [16,19,30,31]. The reasons for this may vary between Western and non-Western immigrants. While most Western immigrants in Denmark originate from nations with largely comparable healthcare services, culture and socioeconomic development, their participation rates in screening are lower. This may be due to continued reliance on healthcare services in their home countries, but due to the unavailability of health data from countries other than Denmark, we cannot validate or refute this hypothesis. This could be of key interest in future research. Conversely, the lower participation rates among non-Western immigrants are often attributed, among other factors, to language barriers, limited awareness and knowledge, and cultural differences [31].

However, after adjustment, the association for non-Western immigrants substantially decreased when comparing non-participation to attending two and three screenings. Furthermore, non-Western immigrants were found to be less prone to non-participation compared to Western immigrants. This observation may suggest that social determinants play a more prominent role in influencing non-participation in cancer screening than ethnicity for non-Western immigrants. Women were included in our study only if they had resided continuously in Denmark for a minimum of six years, providing time for adaption and understanding of the Danish health system.

Previous research has indicated that immigrants, particularly non-Western individuals, exhibit a lower baseline risk of cancer, including cervical, colorectal and breast cancer [32,33]. However, this risk tends to align with that of the host population over time spent in the new country [34], although the exact length of stay was not available in our dataset.

Living alone was associated with increased odds of non-participation, consistent with the findings in previous studies [16,19,20,27], encompassing colorectal, cervical and breast cancer screening separately. Possible explanations could include a lack of support and decision-making assistance from a partner, or a perception of reduced accountability to a partner [35,36].

A socioeconomic gradient has been firmly established across cancer screening programs, as noted in a review by Young and Robb [25]. Consistent with other European studies examining non-participation in each program, our results demonstrated an elevated likelihood of non-participation for women currently outside the labor force [19,20], women with an education of 10 years or less [19,20,27], and as income declines [17,19,36,37]. Furthermore, with each increment in screening participation, the association with non-participation intensifies. All three cancer screening programs in Denmark are provided free of charge, hence factors other than financial considerations must contribute to non-participation. The Danish system provides practically complete invitation coverage in all three cancer screening programs, and private options and opportunistic screenings are not readily accessible for breast cancer or colorectal cancer.

Women with the highest levels of education were slightly more likely to be non-participants than women with intermediate-level education, indicating a U-shaped association, as also previously reported [17,20,38]. However, the association was only statistically significant when comparing none to three screenings attended. Our criteria for being in the high-education group were more stringent than in many other studies that demonstrated a linear correlation between the length of education and participation, which may explain the differing findings [19,27]. The reasons for non-participation among highly educated women may differ from those among less educated. Women with shorter education may face challenges related to e.g. health literacy levels [39]. Conversely, it has been suggested that well-educated women in leadership positions may be making a more deliberate choice not to participate in cancer screening due to ongoing debates regarding its benefits and harms [16,17,38]. Another reason could be a heavier workload and reluctance to take time off for a mammography appointment and general practitioner visit for cervical cancer screening. This aspect may partly explain why retired women had lower odds of complete non-participation compared with employed women, in alignment with findings in other studies [17,40]. However, this explanation does not apply to self-sampled colorectal cancer screening.

As different socioeconomic groups may have distinct ways of engaging in health prevention, research into what happens in the interaction between resident and the healthcare system is needed to address the inequities shown in this study. Prioritizing interventions aimed at socioeconomically vulnerable groups holds significant potential for reducing inequity across Danish cancer

screening programs.

5. Conclusions

While our findings align with those from previous studies that focused on individual programs, our study adds value by providing a more nuanced understanding of the complex interplay of factors influencing non-participation in multiple cancer screening programs. The direction of the associations mirrors those observed within each program independently, but our findings reveal a clear gradient when comparing non-participants to those participating in one, two, and three programs, with disparities increasing at each level. This underscores the necessity of approaches to address participation barriers across diverse screening context for socioeconomic vulnerable groups.

Data availability

In compliance with Danish data privacy regulations, the datasets generated and analyzed in this project are not publicly available and are restricted to pre-approved researchers at Statistics Denmark. Access to the data may be granted upon submission of a reasonable scientific proposal to Statistics Denmark, limited to the scope of the current project and solely for scientific purposes.

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CRediT authorship contribution statement

Anne Dorte Lerche Helgestad: Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization. **Berit Andersen:** Writing – review & editing, Supervision, Methodology, Conceptualization. **Sisse Helle Njor:** Writing – review & editing, Methodology, Formal analysis. **Mette Bach Larsen:** Writing – review & editing, Supervision, Methodology, Data curation, Conceptualization.

Declaration of competing interest

None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2024.e31163.

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