



# Lower attendance rates in BreastScreen Norway among immigrants across all levels of socio-demographic factors: a population-based study

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## Abstract

**Background** Several studies have shown that immigrants attend mammographic screening less frequently than non-immigrants. Studies have also shown that attendance is influenced by socio-demographic factors. We aimed to describe the relationship between socio-demographic factors and first attendance among immigrant and non-immigrant women invited to BreastScreen Norway.

**Methods** Our cohort consisted of 885,979 women invited to BreastScreen Norway for their first time between 1996 and 2015. We merged individual-level socio-demographic data to attendance data corresponding to women's first invitation to the program. Using Poisson regression, we calculated rate ratios with 95% confidence intervals (95% CI) for attendance, stratified by region of origin. Covariates of interest included age, income, education level, employment status, marital status, citizenship and years since immigration, among others.

**Results** Fifty-three percent of immigrants and 76% of non-immigrants attended mammographic screening after their first invitation; immigrants as a whole had lower attendance rates across all socio-demographic factors. However, the association between socio-demographic factors and attendance varied between immigrant groups. For all immigrants, no recorded education demonstrated the strongest association with non-attendance compared with  $\leq 10$  years recorded education (RR<sub>adj</sub>: 0.69, 95% CI: 0.67–0.71). Other factors associated with non-attendance were low income, living in Oslo, not being employed and being a recent immigrant.

**Conclusion** The association between socio-demographic factors and mammographic screening attendance differed between immigrant groups. Further studies and preventive health measures should take into account that considering immigrants as a homogeneous group may lead to less effective interventions.

**Keywords** Breast Cancer · Ethnicity · Health inequalities · Screening · Migration

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## Introduction

Breast cancer is the most common cancer and the leading cause of cancer death among women worldwide (Ferlay et al. 2015). However, breast cancer incidence and mortality rates vary greatly across the world (Ferlay et al. 2015). While incidence rates are lowest in Africa and Asia, mortality rates are highest in Africa (Ferlay et al. 2015). Disparities in breast cancer mortality may be related to the availability of diagnostics and treatment and of access to screening (World Health Organization 2018).

Over the past decades, many high-income countries have implemented mammographic screening as a strategy to reduce breast cancer mortality (Youlten et al. 2012). The rationale behind mammographic screening is to detect breast cancer at an early stage requiring less advanced treatment and thereby reducing morbidity and mortality from the disease (Lauby-Secretan et al. 2015; Marmot et al. 2013). A high attendance rate is necessary to reduce breast cancer mortality through

organized mammographic screening; the European guidelines indicate that an attendance rate of 70% is acceptable and 75% is desirable (Perry et al. 2008).

Low income, lack of health insurance and other socio-demographic factors have been associated with screening attendance below recommended levels given in the European guidelines (Perry et al. 2008; Schueler et al. 2008; Zackrisson et al. 2004). In particular, studies from Europe, North America and Oceania have identified disproportionately low attendance among immigrants compared with non-immigrants (Bhargava et al. 2018). Additionally, some groups of immigrant women are more likely to be diagnosed with more advanced disease and thus experience higher rates of breast cancer mortality (Latif et al. 2015; Thøgersen et al. 2017).

Increasing international migration makes socio-demographic disparities in access to and outcomes from screening among immigrants a topical issue. However, many studies lack information about immigration status or make use of self-reported data (Berens et al. 2014; Weber et al. 2014). Immigrant women represent highly heterogeneous groups in terms of pre-migratory, historical, cultural and economic circumstances. They may therefore have varying socio-demographic characteristics that could differentially influence screening attendance compared with other immigrant groups, non-immigrants and second generation immigrants. This makes it important to investigate attendance among groups of immigrants.

Overall screening attendance rates are higher in the Scandinavian countries than in many other countries offering organized mammographic screening (International Cancer Screening Network 2016). The annual attendance rate in BreastScreen Norway is about 75% (Sebuodegard et al. 2016). However, we have observed that immigrants have an attendance rate that is 23 percentage points lower than non-immigrants' after their first invitation to the program, 76% versus 53% (Bhargava et al. 2017).

All inhabitants in Norway are assigned a unique personal identification number (PIN) (The Norwegian Tax Administration 2018). Women targeted by BreastScreen Norway are identified through their PIN, and the PIN allows us to link individual screening data from the Cancer Registry of Norway with socio-demographic data from Statistics Norway. In this study, we took advantage of individually linked data to identify the extent to which socio-demographic factors were associated with attendance among immigrant and non-immigrant women invited to the program during the period from 1996 to 2015.

## Materials and methods

BreastScreen Norway started in 4 of 19 Norwegian counties in 1996. The program expanded gradually, covering all 19 counties by 2005. All women born in birth cohorts

corresponding to age 50 to 69 at the start of a screening round receive an invitation every 2 years by a personal letter stating a time and place for examination. Screening takes place at stationary units in populated areas, whereas mobile units serve many rural areas. Non-attending women receive a reminder letter 4–8 weeks after their scheduled appointment. The attendance rate is 70% after initial invitations, increasing to 75% after reminders are sent. Women pay a user fee of 240 NOK (about €26) to gain access to screening and any required recall and diagnostic workup (The Norwegian Breast Cancer Screening Program 2017).

The Regional Committees for Medical and Health Research Ethics (REC 2013/795) approved this study.

## Data sources and variables

Our study population included 885,979 women with no history of breast cancer who received their first invitation to the program between 1996 and 2015. The Cancer Registry of Norway registers information about all cancers diagnosed in Norway as well all information about screening invitations and attendance in BreastScreen Norway (The Norwegian Breast Cancer Screening Program 2017). We extracted information regarding women's attendance after their first invitation to the screening program as well as information about breast cancer history from the Cancer Registry of Norway's databases. We merged data from the Cancer Registry with information about date of birth and death and socio-demographic factors (county of residence, country of birth, immigration, emigration, income, net worth, education level, employment status, disability benefit recipient status, marital status and citizenship) from Statistics Norway, using the women's PIN.

Information about age, county of residence, screening year and years since immigration refers to the date of the scheduled screening appointment. Income, net worth, employment status and disability benefit recipient status refer to values from the year prior to the appointment. Employment status was not available prior to 2001. Education level, marital status and citizenship refer to the most recent values available. Income and net worth were categorized into deciles derived from all women aged 25 to 67 to exclude values from students and pensioners.

We adopted Statistics Norway's definition of immigrants: persons born abroad with two foreign-born parents and four foreign-born grandparents (Statistics Norway 2017b). All other women were defined as non-immigrants. Our approach to selecting appropriate geographical divisions to represent region of origin was two-fold. First, we considered the United Nations' (UN) Population Division of regions as an unbiased geographical division. Second, we modified these 23 regions to create 9 regions (Norway, Western Europe, The Baltic Countries, Southern & Eastern Europe, Northern Africa &

Western Asia, Eastern Africa, Rest of Africa, Rest of Asia and The Americas & the Pacific), based on political, historical and cultural similarities, geographical proximity and similar screening rates for women born in these regions (Appendix).

### Statistical analysis

We performed descriptive statistics of attendance rates stratified by region of origin for the following socio-demographic factors: age, income, net worth, education level, employment status, disability benefit recipient status, marital status, citizenship, place of residency, screening year and years since immigration. Further, we calculated unadjusted and adjusted rate ratios (RR and RR<sub>adj</sub>, respectively) with 95% confidence intervals (95% CI) using Poisson regression with robust variance to assess the relationship between attendance and these socio-demographic factors, stratified by region. In total, there were 11 multivariate models: one for all women, one for non-immigrants, one for immigrants and one for each of the eight regions of origin. Additionally, we used unadjusted rate ratios to compare immigrants' and non-immigrants' attendance rates for each socio-demographic factor. We created a dummy level to represent missing employment status information prior to 2001. We assessed pairwise associations between covariates of interest to examine collinearity. All observed coefficients of determination ( $R^2$ ) were  $\leq 0.25$ . We used Stata MP version 15.0 for all analyses.

### Results

The study cohort consisted of 885,979 women, 72,207 of whom were immigrants (Table 1). The largest group of immigrants came from Western Europe ( $n = 24,509$ ), followed by Rest of Asia ( $n = 18,169$ ) and Southern & Eastern Europe ( $n = 14,913$ ) (Appendix Table 1). Immigrants were more likely than non-immigrants to have an income in the lowest decile (28% versus 8%). Among immigrants, those from Northern Africa and Western Asia and The Baltic Countries were most likely to have an income in the lowest decile (42 and 39%, respectively). A higher proportion of immigrants had no recorded education compared with non-immigrants (17% versus 1%). A total of 26% of immigrants were living in the capital city of Oslo compared with 11% of non-immigrants. Immigrants from the Baltic Countries had the lowest proportion living in Oslo (8%).

Among all women, we observed a lower crude attendance rate among those with no recorded education, who were unemployed or who lived in Oslo (Table 2). Immigrants had lower attendance rates than non-immigrants across all levels of socio-demographic factors (Fig. 1 and Table 2). Women from most regions had lower attendance if they were not married, 25%–56% for immigrants and 66% for non-immigrants.

For all immigrant groups, income in the lowest decile was associated with low attendance, ranging from 24 to 52%, compared with 71% for non-immigrants in the lowest income decile. We did not observe a similar finding for net worth. Overall, screening attendance was 57% among immigrants receiving disability benefits and 53% among immigrants not receiving such benefits. We observed the opposite among non-immigrants and immigrants from the Rest of Africa (70 and 78%, and 46 and 54%, respectively, for those receiving disability benefits versus those not receiving benefits). For most immigrant groups, the attendance rate increased with years since immigration.

Generally, the risk ratios for attendance were higher in the univariate models. Discrepancies between the univariate and multivariate models were more pronounced for immigrants than non-immigrants (Tables 3, 4 and Appendix Table 2). For all women combined, the strongest association was observed between education and attendance (RR<sub>adj</sub> 0.61, 95% CI 0.60–0.62 for no recorded education versus less than 10 years) (Table 3). Having an income in the lowest decile, not being employed, being separated or not married, having foreign citizenship or living in Oslo was also associated with lower risk of attendance among all women combined. With the exception of citizenship for immigrants, the abovementioned associations persisted when stratified into non-immigrants and all immigrants. The magnitudes of the adjusted risk ratios were similar for non-immigrants and all immigrants; however, income was more strongly associated with attendance among immigrants.

The association between socio-demographic factors and attendance among immigrants varied when stratified by region of origin (Table 4). Having an income in the lowest decile was associated with lower attendance for most groups. Being unemployed compared with being employed was associated with statistically significantly lower attendance for women from Western Europe, Eastern Africa and the Rest of Asia. The RR<sub>adj</sub> for attendance among women from Eastern Africa not receiving disability benefits compared with those receiving these benefits was 0.74, 95% CI 0.61–0.89. Further, living outside Oslo was associated with increased attendance among immigrants overall. This relationship was observed in the stratified models but did not reach statistical significance for women from the Baltic Countries and Rest of Africa. The majority of recent immigrants had lower attendance than immigrants who had been in Norway for at least 10 years, except for immigrants from Eastern Africa, where the opposite was observed.

### Discussion

In this study of 885,979 women with no history of breast cancer invited to organized mammographic screening in Norway, we observed lower attendance rates among

**Table 1** Socio-demographic characteristics of women invited to attend BreastScreen Norway, 1996–2015 (see Appendix Table 1 for characteristics stratified by region of origin)

	All ( <i>n</i> = 885,979)	Non-immigrants ( <i>n</i> = 813,772)	All immigrants ( <i>n</i> = 72,207)
<b>Age</b>			
< 55 years	589,382 (67%)	536,498 (66%)	52,884 (73%)
55–59 years	121,098 (14%)	112,429 (14%)	8669 (12%)
60–64 years	93,003 (11%)	86,950 (11%)	6053 (8%)
> 64 years	82,496 (9%)	77,895 (10%)	4601 (6%)
<b>Income</b>			
1st decile	88,580 (10%)	68,663 (8%)	19,917 (28%)
2nd–9th decile	701,390 (79%)	657,870 (81%)	43,520 (60%)
10th decile	93,028 (11%)	86,868 (11%)	6160 (9%)
Missing	2981 (0%)	371 (0%)	2610 (4%)
<b>Net worth</b>			
1st decile	53,609 (6%)	49,627 (6%)	3982 (6%)
2nd–9th decile	699,105 (79%)	638,148 (78%)	60,957 (84%)
10th decile	131,923 (15%)	125,932 (16%)	5991 (8%)
Missing	1342 (0%)	65 (0%)	1277 (2%)
<b>Education</b>			
≤ 10 years	244,347 (28%)	227,753 (28%)	16,594 (23%)
11–13 years	399,426 (45%)	380,877 (47%)	18,549 (26%)
14–17 years	187,454 (21%)	170,345 (21%)	17,109 (24%)
> 17 years	37,678 (4%)	30,234 (4%)	7444 (10%)
No recorded	17,074 (2%)	4563 (1%)	12,511 (17%)
<b>Employment status</b>			
Outside workforce	166,045 (19%)	148,201 (18%)	17,844 (25%)
Employed	474,798 (54%)	444,711 (55%)	30,087 (42%)
Unemployed	7113 (1%)	5642 (1%)	1471 (2%)
Missing	238,023 (27%)	215,218 (26%)	22,805 (32%)
<b>Disability benefit recipient status</b>			
No	694,653 (78%)	630,816 (78%)	63,837 (88%)
Yes	191,326 (22%)	182,956 (23%)	8370 (12%)
<b>Marital status</b>			
Not married	86,989 (10%)	81,709 (10%)	5280 (7%)
Married/partner	486,653 (55%)	445,133 (55%)	41,520 (58%)
Widow	137,979 (16%)	127,927 (16%)	10,052 (14%)
Separated	174,358 (20%)	159,003 (20%)	15,355 (21%)
<b>Citizenship</b>			
Norwegian	848,114 (96%)	812,077 (100%)	36,037 (50%)
Other	37,865 (4%)	1695 (0%)	36,170 (50%)
<b>Living in Oslo</b>			
No	779,184 (88%)	725,616 (89%)	53,568 (74%)
Yes	106,795 (12%)	88,156 (11%)	18,639 (26%)
<b>Screening appointment year</b>			
1996–2005	570,010 (64%)	536,770 (66%)	33,240 (46%)
2006–2015	315,969 (36%)	277,002 (34%)	38,967 (54%)
<b>Years since immigration</b>			
< 5 years			17,038 (24%)
5–9 years			7579 (11%)
10–14 years			7562 (11%)
> 14 years			39,935 (55%)
Missing			93 (0%)

**Table 2** Screening attendance by socio-demographic factors for immigrant and non-immigrant women invited to attend BreastScreen Norway, 1996–2015

	All (74%)	Non-immigrants (76%)	All immigrants (53%)	Western Europe (66%)	The Baltic countries (32%)	Southern & Eastern Europe (47%)	Northern Africa & Western Asia (41%)	Eastern Africa (34%)	Rest of Africa (53%)	Rest of Asia (47%)	The Americas & the Pacific (55%)
<b>Age</b>											
<55 years	73%	75%	54%	66%	34%	50%	44%	36%	53%	51%	55%
55–59 years	77%	79%	51%	65%	24%	39%	31%	29%	43%	37%	52%
60–64 years	77%	79%	50%	68%	27%	35%	28%	23%	65%	31%	53%
> 64 years	74%	75%	52%	70%	38%	36%	24%	23%	54%	26%	63%
<b>Income</b>											
1st decile	64%	71%	39%	52%	25%	35%	33%	24%	38%	36%	41%
2nd–9th decile	76%	77%	60%	70%	37%	55%	47%	38%	59%	55%	63%
10th decile	75%	76%	67%	70%	54%	62%	60%	53%	63%	61%	64%
Missing	25%	31%	25%	35%	11%	20%	23%	25%	29%	21%	21%
<b>Net worth</b>											
1st decile	69%	70%	60%	64%	36%	58%	59%	52%	53%	56%	62%
2nd–9th decile	74%	76%	52%	65%	32%	46%	40%	32%	52%	46%	54%
10th decile	79%	79%	69%	73%	65%	60%	53%	56%	71%	63%	68%
Missing	25%	32%	25%	32%	17%	20%	26%	28%	42%	24%	22%
<b>Education</b>											
≤ 10 years	70%	72%	52%	67%	41%	47%	44%	32%	54%	48%	56%
11–13 years	77%	78%	60%	69%	33%	50%	49%	49%	62%	56%	62%
14–17 years	77%	78%	63%	70%	38%	55%	45%	51%	57%	58%	62%
> 17 years	71%	73%	59%	66%	43%	55%	52%	45%	45%	57%	57%
No recorded	34%	48%	28%	36%	20%	24%	32%	21%	37%	29%	27%
<b>Employment status</b>											
Outside workforce	63%	66%	43%	57%	29%	39%	39%	26%	38%	41%	46%
Employed	77%	78%	62%	70%	38%	56%	56%	49%	61%	59%	65%
Unemployed	61%	65%	46%	54%	30%	46%	52%	27%	45%	45%	47%
Missing	76%	79%	49%	65%	22%	39%	30%	28%	53%	37%	50%
<b>Disability benefit recipient status</b>											
No	76%	78%	53%	66%	32%	47%	40%	33%	54%	47%	55%
Yes	69%	70%	57%	68%	75%	52%	45%	44%	46%	49%	60%
<b>Marital status</b>											
Not married	65%	66%	45%	56%	25%	32%	34%	35%	39%	36%	40%
Married/partner	78%	80%	56%	69%	33%	50%	43%	34%	59%	50%	58%
Widow	76%	78%	52%	72%	42%	41%	33%	33%	51%	40%	65%
Divorced/separated	66%	68%	50%	60%	32%	45%	42%	33%	48%	45%	49%
<b>Citizenship</b>											
Norwegian	75%	76%	56%	71%	59%	56%	43%	36%	59%	52%	64%
Other	51%	64%	50%	64%	29%	36%	31%	29%	37%	33%	48%

Table 2 (continued)

	All (74%)	Non-immigrants (76%)	All immigrants (53%)	Western Europe (66%)	The Baltic countries (32%)	Southern & Eastern Europe (47%)	Northern Africa & Western Asia (41%)	Eastern Africa (34%)	Rest of Africa (53%)	Rest of Asia (47%)	The Americas & the Pacific (55%)
Living in Oslo											
No	76%	77%	56%	68%	32%	48%	44%	36%	53%	51%	59%
Yes	62%	66%	45%	59%	34%	43%	37%	30%	53%	40%	44%
Screening appointment year											
1996–2005	76%	77%	57%	69%	53%	47%	37%	32%	57%	45%	58%
2006–2015	71%	74%	50%	62%	31%	47%	43%	34%	51%	48%	52%
Years since immigration											
< 5 years			34%	43%	25%	32%	30%	27%	35%	31%	33%
5–9 years			46%	58%	48%	45%	36%	32%	44%	42%	52%
10–14 years			53%	66%	53%	55%	45%	30%	51%	50%	55%
> 14 years			63%	72%	60%	59%	47%	43%	62%	54%	62%
Missing			76%	79%		67%	0%			0%	91%

**Fig. 1** Unadjusted rate ratios comparing mammographic screening attendance among immigrants to attendance among non-immigrants (reference group) for all levels of socio-demographic factors

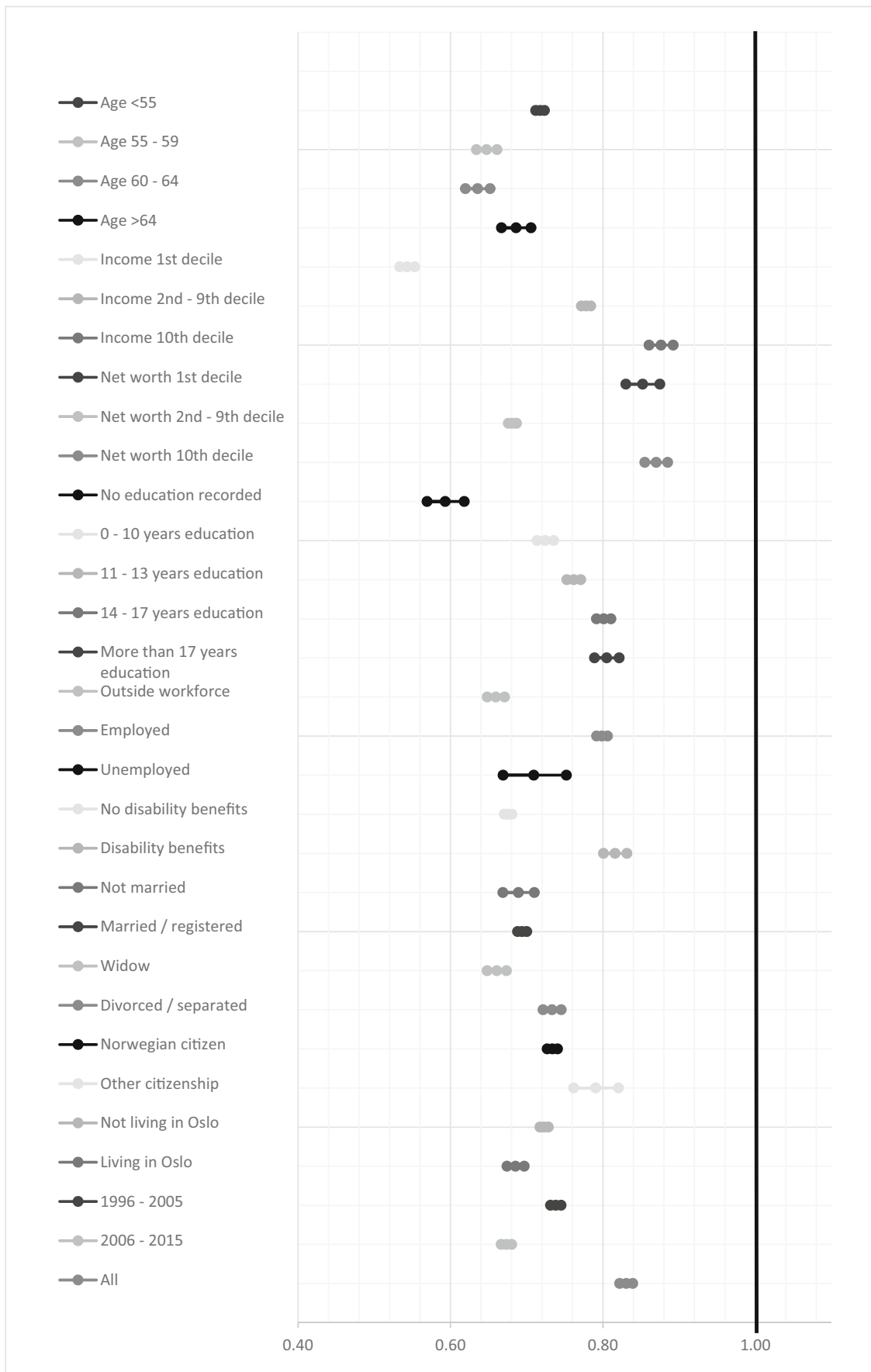
immigrants than non-immigrants across all levels of the socio-demographic factors studied. These rates varied for immigrants from different regions and by socio-demographic factors.

Compared with  $\leq 10$  years of education, no recorded education demonstrated the strongest and most consistent negative association with attendance for women from all regions, for both immigrants and non-immigrants. Our findings indicate that women with no recorded education might form a particularly vulnerable group that may need increased attention when planning information activities and interventions regarding screening attendance. If no record of education represents no education, possible explanations for lower attendance could include particular health, social and/or economic circumstances that negatively influenced women's ability to follow a school system and thereby understand written information in Norwegian, including screening invitations, or the ability to prioritize screening.

We also found that living in Oslo was associated with lower attendance for most women. This is consistent with results from other studies analyzing attendance rates among women residing in urban versus rural areas (National Health Service 2017). Urban areas such as Oslo typically have larger immigrant populations, more women with higher education and increased access to opportunistic screening—all factors that could negatively affect attendance at organized screening. Indeed, we observed a higher proportion of immigrants and women with higher education in Oslo than other parts of Norway. However, little is known about opportunistic screening attendance in Norway, and this information was not available for our study. More research is needed to understand how urban settings influence attendance.

Lower attendance rates were observed among women who had an income in the lowest decile, or who were unemployed, compared with those with higher income or who were employed, respectively. Our findings are in line with results from other studies reporting an association between low income or unemployment and low attendance (Lagerlund et al. 2002; Vahabi et al. 2016). Financial and/or social concerns might reduce the opportunity to prioritize time or money for screening. Although the user fee for mammographic screening in Norway may be considered affordable, women with a low income or women who are unemployed might not prioritize spending their money on screening. We also observed that the relationship between income and screening attendance was more pronounced among immigrants than non-immigrants, suggesting that income is likely a stronger determinant of screening attendance among immigrants than non-immigrants.

Like studies from other countries (Schueler et al. 2008; Vahabi et al. 2016), our study showed that recent immigration



**Table 3** Multivariate analysis of attendance by socio-demographic factors for immigrant and non-immigrant women invited to attend BreastScreen Norway, 1996–2015

	All	Non-immigrants	All immigrants
<b>Age</b>			
< 55 years	1.00 (ref)	1.00 (ref)	1.00 (ref)
55–59 years	1.03 (1.03–1.04)	1.03 (1.03–1.04)	1.03 (1.00–1.05)
60–64 years	1.06 (1.05–1.06)	1.06 (1.05–1.06)	1.03 (1.00–1.06)
> 64 years	1.05 (1.04–1.05)	1.04 (1.03–1.04)	1.06 (1.03–1.09)
<b>Income</b>			
1st decile	1.00 (ref)	1.00 (ref)	1.00 (ref)
2nd–9th decile	1.10 (1.09–1.11)	1.06 (1.06–1.07)	1.22 (1.20–1.25)
10th decile	1.09 (1.08–1.10)	1.05 (1.04–1.05)	1.23 (1.20–1.27)
<b>Net worth</b>			
1st decile	1.00 (ref)	1.00 (ref)	1.00 (ref)
2nd–9th decile	1.05 (1.05–1.06)	1.06 (1.05–1.06)	1.01 (0.98–1.04)
10th decile	1.08 (1.08–1.09)	1.08 (1.07–1.08)	1.06 (1.03–1.10)
<b>Education</b>			
≤ 10 years	1.00 (ref)	1.00 (ref)	1.00 (ref)
11–13 years	1.07 (1.07–1.07)	1.07 (1.06–1.07)	1.09 (1.07–1.11)
14–17 years	1.08 (1.07–1.08)	1.08 (1.07–1.08)	1.12 (1.10–1.14)
> 17 years	1.03 (1.03–1.04)	1.04 (1.03–1.05)	1.09 (1.06–1.11)
No recorded	0.61 (0.60–0.62)	0.74 (0.72–0.76)	0.69 (0.67–0.71)
<b>Employment status</b>			
Outside workforce	1.04 (1.02–1.06)	1.03 (1.01–1.05)	0.95 (0.90–1.01)
Employed	1.20 (1.18–1.22)	1.18 (1.15–1.20)	1.13 (1.06–1.19)
Unemployed	1.00 (ref)	1.00 (ref)	1.00 (ref)
<b>Disability benefit recipient status</b>			
No	1.03 (1.03–1.04)	1.04 (1.04–1.05)	1.00 (0.98–1.02)
Yes	1.00 (ref)	1.00 (ref)	1.00 (ref)
<b>Marital status</b>			
Not married	1.00 (ref)	1.00 (ref)	1.00 (ref)
Married/partner	1.16 (1.15–1.16)	1.17 (1.16–1.17)	1.16 (1.12–1.19)
Widow	1.12 (1.11–1.13)	1.13 (1.13–1.14)	1.09 (1.05–1.13)
Separated	1.00 (1.00–1.01)	1.01 (1.01–1.02)	0.98 (0.95–1.02)
<b>Citizenship</b>			
Norwegian	1.21 (1.20–1.22)	1.11 (1.07–1.15)	0.98 (0.96–0.99)
Other	1.00 (ref)	1.00 (ref)	1.00 (ref)
<b>Living in Oslo</b>			
No	1.22 (1.21–1.22)	1.20 (1.19–1.20)	1.22 (1.20–1.24)
Yes	1.00 (ref)	1.00 (ref)	1.00 (ref)
<b>Screening appointment year</b>			
1996–2005	1.00 (ref)	1.00 (ref)	1.00 (ref)
2006–2015	0.99 (0.98–0.99)	1.00 (0.99–1.00)	0.96 (0.94–0.97)
<b>Years since immigration</b>			
< 5 years			1.00 (ref)
5–9 years			1.07 (1.03–1.11)
10–14 years			1.22 (1.18–1.26)
> 14 years			1.33 (1.29–1.37)



**Table 4** Multivariate analysis of attendance by socio-demographic factors for immigrant and non-immigrant women invited to attend BreastScreen Norway, 1996–2015, stratified by region of origin

	Western Europe	The Baltic countries	Southern & Eastern Europe	Northern Africa & Western Asia	Eastern Africa	Rest of Africa	Rest of Asia	The Americas & the Pacific
<b>Age</b>								
< 55 years	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
55–59 years	1.01 (0.99–1.04)	0.91 (0.68–1.22)	0.98 (0.91–1.05)	0.90 (0.75–1.09)	1.11 (0.82–1.51)	0.99 (0.72–1.35)	0.96 (0.89–1.04)	1.14 (1.05–1.23)
60–64 years	1.04 (1.01–1.07)	0.94 (0.61–1.46)	0.92 (0.84–1.01)	0.70 (0.53–0.91)	0.89 (0.62–1.27)	1.57 (1.20–2.05)	0.89 (0.80–0.98)	1.12 (1.02–1.23)
> 64 years	1.05 (1.02–1.09)	0.93 (0.53–1.65)	0.98 (0.88–1.09)	0.79 (0.58–1.07)	0.85 (0.57–1.28)	1.46 (1.10–1.94)	0.81 (0.71–0.93)	1.16 (1.07–1.26)
<b>Income</b>								
1st decile	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
2nd–9th decile	1.16 (1.12–1.20)	1.25 (1.01–1.53)	1.21 (1.14–1.27)	1.22 (1.11–1.35)	1.31 (1.09–1.57)	1.28 (1.01–1.61)	1.21 (1.16–1.27)	1.23 (1.15–1.33)
10th decile	1.15 (1.11–1.20)	1.22 (0.83–1.78)	1.25 (1.16–1.35)	1.26 (1.03–1.54)	1.34 (1.01–1.79)	1.26 (0.94–1.69)	1.18 (1.10–1.27)	1.27 (1.15–1.39)
<b>Net worth</b>								
1st decile	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
2nd–9th decile	1.06 (1.02–1.10)	1.48 (0.84–2.61)	1.01 (0.94–1.07)	0.85 (0.73–0.97)	0.93 (0.76–1.15)	1.10 (0.86–1.40)	1.00 (0.94–1.06)	0.96 (0.89–1.05)
10th decile	1.08 (1.03–1.13)	1.70 (0.89–3.24)	1.01 (0.93–1.11)	0.87 (0.70–1.07)	1.01 (0.74–1.39)	1.19 (0.86–1.64)	1.10 (1.03–1.18)	1.04 (0.94–1.14)
<b>Education</b>								
≤ 10 years	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
11–13 years	1.02 (0.99–1.05)	0.93 (0.71–1.22)	1.06 (1.01–1.11)	1.11 (1.00–1.23)	1.35 (1.15–1.58)	1.05 (0.89–1.23)	1.10 (1.05–1.14)	1.08 (1.01–1.15)
14–17 years	1.05 (1.02–1.08)	1.18 (0.91–1.53)	1.10 (1.05–1.16)	1.00 (0.89–1.12)	1.39 (1.16–1.65)	0.94 (0.78–1.14)	1.12 (1.07–1.16)	1.11 (1.03–1.19)
> 17 years	0.99 (0.96–1.03)	1.19 (0.91–1.54)	1.12 (1.06–1.19)	1.14 (0.97–1.33)	1.19 (0.89–1.60)	0.83 (0.61–1.14)	1.15 (1.08–1.22)	1.07 (0.98–1.16)
No recorded	0.69 (0.64–0.74)	0.69 (0.51–0.93)	0.67 (0.61–0.74)	0.85 (0.76–0.94)	0.71 (0.58–0.87)	0.84 (0.64–1.10)	0.75 (0.70–0.79)	0.65 (0.56–0.74)
<b>Employment status</b>								
Outside workforce	1.01 (0.89–1.15)	1.13 (0.69–1.86)	0.87 (0.78–0.96)	0.76 (0.64–0.90)	1.11 (0.75–1.64)	0.84 (0.50–1.40)	1.01 (0.90–1.13)	0.99 (0.81–1.22)
Employed	1.16 (1.03–1.32)	1.20 (0.75–1.93)	1.03 (0.94–1.14)	0.92 (0.77–1.10)	1.58 (1.07–2.33)	1.08 (0.66–1.76)	1.17 (1.05–1.31)	1.18 (0.96–1.44)
Unemployed	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
<b>Disability benefit recipient status</b>								
No	1.02 (0.99–1.05)	0.87 (0.60–1.26)	0.98 (0.93–1.04)	0.94 (0.85–1.04)	0.74 (0.61–0.89)	1.29 (1.01–1.65)	1.00 (0.95–1.05)	1.02 (0.95–1.09)
Yes	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
<b>Marital status</b>								
Not married	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Married/partner	1.13 (1.10–1.17)	1.15 (0.90–1.46)	1.34 (1.21–1.48)	1.14 (0.87–1.50)	1.06 (0.85–1.31)	1.41 (0.98–2.02)	1.30 (1.16–1.45)	1.27 (1.13–1.43)
Widow	1.10 (1.06–1.15)	1.35 (0.95–1.91)	1.21 (1.08–1.35)	1.05 (0.78–1.41)	1.27 (1.00–1.63)	1.23 (0.83–1.84)	1.19 (1.05–1.34)	1.27 (1.11–1.45)
Separated	0.99 (0.96–1.03)	1.06 (0.81–1.38)	1.13 (1.02–1.26)	0.99 (0.75–1.31)	0.91 (0.72–1.14)	1.09 (0.75–1.59)	1.09 (0.97–1.22)	1.01 (0.90–1.15)
<b>Citizenship</b>								
Norwegian	0.99 (0.97–1.01)	1.28 (1.03–1.59)	1.15 (1.10–1.20)	1.07 (0.94–1.22)	1.09 (0.92–1.30)	1.15 (0.92–1.43)	1.19 (1.13–1.25)	1.14 (1.09–1.20)
Other	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)

Table 4 (continued)

	Western Europe	The Baltic countries	Southern & Eastern Europe	Northern Africa & Western Asia	Eastern Africa	Rest of Africa	Rest of Asia	The Americas & the Pacific
Living in Oslo								
No	1.17 (1.14–1.20)	1.12 (0.85–1.48)	1.16 (1.10–1.21)	1.14 (1.04–1.24)	1.25 (1.09–1.42)	0.97 (0.84–1.11)	1.19 (1.15–1.23)	1.27 (1.19–1.35)
Yes	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Screening appointment year								
1996–2005	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
2006–2015	1.01 (0.99–1.04)	0.86 (0.63–1.17)	1.00 (0.96–1.05)	0.85 (0.77–0.94)	0.97 (0.82–1.16)	1.09 (0.90–1.33)	0.96 (0.92–0.99)	1.02 (0.96–1.08)
Years since immigration								
< 5 years	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
5–9 years	1.09 (1.02–1.15)	1.38 (1.15–1.66)	1.04 (0.97–1.11)	0.95 (0.81–1.12)	0.83 (0.67–1.04)	0.99 (0.67–1.46)	0.90 (0.83–0.98)	1.08 (0.95–1.24)
10–14 years	1.21 (1.14–1.28)	1.30 (0.98–1.73)	1.16 (1.09–1.24)	1.16 (1.00–1.35)	0.75 (0.59–0.94)	1.12 (0.79–1.57)	1.02 (0.95–1.10)	1.11 (0.97–1.26)
> 14 years	1.26 (1.21–1.32)	1.34 (1.01–1.79)	1.24 (1.17–1.32)	1.19 (1.03–1.36)	0.86 (0.71–1.05)	1.30 (0.96–1.77)	1.02 (0.96–1.09)	1.14 (1.02–1.27)

(less than 5 years) was associated with lower attendance for women from most regions. This might indicate that immigrants who have resided longer in a country are more likely to make use of the public services in that country, including health services such as mammographic screening. However, we did not observe this effect among women from Eastern Africa. Women from Eastern Africa also differed from the other immigrant groups with respect to the association between not receiving disability benefits and attendance, as shown by the  $RR_{adj}$ . In our study population, women from Somalia represent a substantial proportion of the Eastern Africa group (44.3%). Somalis in Norway have lower income (52% of the median income in Norway, SSB 2009–2016) (Statistics Norway 2017d) and employment levels (32.4% in 2015) (Statistics Norway 2017a) than immigrants and non-immigrants alike. They also have the lowest mammographic screening attendance rates (Bhargava et al. 2017). As a result, this group may benefit from a targeted approach when planning interventions to increase attendance among immigrants.

Our results demonstrated that immigrants attended screening less often than non-immigrants and further demonstrated that some socio-demographic factors may have a stronger influence on immigrants' attendance at BreastScreen Norway than non-immigrants. Immigrants might face extra challenges navigating health care services due to unfamiliarity with these services or linguistic or cultural differences. Norredam et al. reviewed the access to health care services among immigrants in Europe and found a trend toward lower attendance at screening services among immigrants than non-immigrants (Norredam et al. 2009). Similarly, a recent study found lower attendance rates for immigrants than non-immigrants in the Norwegian cervical cancer screening program (Leinonen et al. 2017). These findings support the hypothesis that the screening disparity observed in this study may be due to systematic health access challenges associated with having an immigrant background.

We did not have information about factors pertaining to linguistic or cultural backgrounds or to pre-migratory factors among women in our study. Understanding how these factors influence screening attendance could be important. For instance, the gender of the radiographer performing the mammogram might constitute a barrier against attendance. Additionally, our analyses were limited by not having information about reasons for immigration. Reasons for immigration differ between and within immigrant groups (Statistics Norway 2017c). If reasons for immigration affect screening attendance, this could be a source of residual confounding in our study. Such confounding could also be caused by other socio-demographic factors we did not have access to, such as traveling distance to the screening unit (Maheswaran et al. 2006) or use of opportunistic screening.

In conclusion, we observed that immigrants had lower attendance at BreastScreen Norway than non-immigrants across all levels of the socio-demographic factors studied. Moreover,

we observed that women's region of origin influenced the effect of the socio-demographic factors on attendance. For the majority of immigrant groups, no recorded education, low income, living in Oslo, not being employed, or being a recent immigrant were associated with lower attendance. Further studies investigating socio-demographic factors, as well as linguistic, cultural and pre-migratory circumstances, are needed to improve the inclusivity of organized mammographic screening.

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### Compliance with ethical standards

**Ethical approval** The Regional Committees for Medical and Health Research Ethics (REC 2013/795) approved this study.

**Conflict of interest** The authors declare that they have no conflicts of interest.

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