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Differences in cervical test coverage by age, socioeconomic status, ethnic origin and municipality type – A nationwide register-based study

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ABSTRACT

An invitational organized cervical cancer screening together with widely spread opportunistic testing has co-existed for decades in Finland. The aim of this study was to examine the coverage of cervical tests by age, socioeconomic status, ethnicity and municipality type within and outside the organized screening program. We had a cohort of women of whom 1,2 million were in the target age range of screening and residing in Finland in 2010–2014. Data on Pap and/or HPV -tests within and outside the screening program were collected from the Mass Screening Registry, the pathology laboratories and the health insurance reimbursement registry and five-year population coverages of tests were reported. The total test coverage was 86.0%; 95% CI, (85.8–86.1), and was notably lower for those with an unknown socioeconomic status and pensioners (68.8%; 95% CI, (67.9–69.6) and 77.1%; 95% CI, (76.5–77.6), respectively) compared to upper-level employers (89.8%; 95% CI, (89.5–90.2)). Coverage was also lower for non-native speaking women (72.4%; 95% CI, (71.8–73.0)) compared to native speakers (86.9%; 95% CI, (86.7–87.0)) and for women living in urban municipalities (85.5%; 95% CI, (85.3–85.7)) compared to semi-urban (87.4%; 95% CI, (87.0–87.8)). Although overall coverage was high, tests within and outside the program seemed to concentrate on women with presumably good access to health services. Tests outside the program were especially common among young women who are at a low risk of invasive cervical cancer. Efforts should be made to reduce excessive opportunistic testing and to increase attendance at the program among hard-to-reach populations.

1. Introduction

Attendance at cancer screening has been found to vary by socioeconomic and other social factors, especially in countries with opportunistic screening programs (Gianino et al., 2018; Walsh et al., 2011; Palència et al., 2010). Opportunistic screening usually requires the initiative of the individual person or her doctor. It is also characterized by high coverage in selected parts of the population which generally have good access to health care services. These people may be screened too frequently, whereas screening coverage tends to be lower in other, less privileged, population groups (Arbyn et al., 2010). In addition, tests outside the screening program are usually not centrally registered in the same way as with organized screening programs and are thus hard to monitor.

Organized screening, by contrast, is often either free of charge for the screened person or up to minimal fee. Everyone in the target population is invited regularly, irrespective of their financial or socioeconomic background – or use of tests outside the program. With optimal target age groups, good population coverage, registration and quality control, organized screening programs effectively reduce cancer burden in the population, and are likely to be cost-effective and minimize harms associated with impaired quality or overly frequent screening (Arbyn et al., 2010; Miles et al., 2004).

Although social differences with respect to attendance at organized screening have been less evident compared to opportunistic, earlier studies have also found differences in attendance rates in countries with well-organized and cost-free screening programs. For example, young age, immigrant background, lower education and being unmarried have been found to be associated with lower attendance to the organized program (Palència et al., 2010; Virtanen et al., 2015). Furthermore, overlapping opportunistic and other cervical testing is known to be common in many countries with organized screening programs (Ponti

Abbreviations: CI, confidence interval; SES, socioeconomic status; ASC-US, atypical squamous cells of undetermined significance; HPV+, positive for human papilloma virus

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et al., 2017), including Finland. The simultaneous use of organized and opportunistic services by different population groups is not well known.

The aim of this study was to assess the coverage of cervical testing and number of tests by socioeconomic status, ethnicity and municipality type, both within and outside the organized screening program. Also, we wanted to assess how testing outside the program affected the coverage differences detected in organized screening between the studied subpopulations – that is, how it possibly influenced equality in the use of screening-like test services. Cervical testing inside and outside the screening program in Finland was now assessed comprehensively for the first time.

2. Methods

The Finnish municipalities are obligated to invite all 30–60-year old women to organized cervical cancer screening. All women are personally invited, and cervical samples are taken by qualified nurses at the screening laboratories every five years. Some municipalities screen also women aged 25 and/or 65. We gathered from the Mass Screening registry on all invitations and screening visits since 1991.

In addition to data on the organized program, we gathered non-organized cervical test data, i.e. data outside the screening program. We received information from 21 different pathology laboratories or hospitals (since the late 1980s), and from the health reimbursement registry (1996–2014). Reimbursements were aimed for women participating to non-organized testing. These different data sources comprised of tests taken in both public and private health care, as well as some tests from the student health services. These cervical samples had been taken either by a qualified nurse or a doctor. In addition, we received a separate data of Pap tests taken in the student health services (YTHS, 2000–2010) which has been used in the studies of Salo et al. (Salo et al., 2014) The complete dataset outside the program included tests done for any reason, including tests performed due to follow-up or symptoms. Therefore, some part of the tests was not taken for screening purposes.

We had a cohort of 2,298,499 women aged 15–99 years, born in 1915–1999 and residing in Finland in 2005–2014. These data were linked with individual-level data on organized screening invitations and visits, and on test dates of Pap and/or HPV -tests outside the screening program. For this cohort, age-specific coverages and number of tests taken outside the program were examined, and both five and ten-year coverages were reported.

We then linked individual-level data on socioeconomic status (SES), mother tongue and residential area for a study cohort of 1,25 million women within the screening target age range of 30–64 years, born in 1950–1984 and residing in Finland in 2010–2014. Data on SES and mother tongue were gathered from Statistics Finland, and data on home municipality from Population Registry. After excluding women with no recorded information on socioeconomic status, mother tongue or home municipalities (2%), we had a total sample of 1,227,459 women. For this cohort, five-year coverages and number of tests outside the program were reported. By choosing the target age range of screening and by reporting five-year coverages, we were able to properly compare the use of tests within and outside the organized program. The combination of different registries forming the study data is depicted in Supplementary Fig. 1.

The index year 2014 was chosen and at most 10-year coverages calculated, since data outside the screening program were the most comprehensive during that time. These time intervals also best describe the current situation, compared to the earliest years.

Occupational level was used as an indicator for socioeconomic status and was categorized in seven classes: 1) employers and self-employed, 2) upper-level employees, 3) lower-level employees, 4) manual workers, 5) unemployed, 6) students, 7) pensioners and 8) unknown/others. The last category consisted of those outside the working force or those without information on socioeconomic status.

The population registries in Finland do not include data on people's ethnic background. However, we considered mother tongue to be a good indicator for ethnicity in this study. Mother tongue was categorized as native (official languages Finnish, Sami or Swedish) and other languages with the most speakers: Russian, Estonia, Thai, Chinese, English and Somali. The Swedish speaking group was also examined separately in the descriptive tables, since it is the largest language minority in Finland.

Comparisons were also made between municipality types (urban, semi-urban and rural). Municipality classification was the same which is used in Statistics Finland: it classifies the municipalities according to the proportion of people living in urban settlements and according to the population size of the largest urban settlement (Statistics Finland, 2015). Classification valid in the year 2014 was used.

Attendance at the organized screening program, attendance at testing outside the program and attendance at any Pap/HPV-testing was examined by crude and age-adjusted percentages and their 95% confidence intervals using Poisson regression. Basic diagnostic checks were conducted for all models. In addition, crude percentages of test intensity by age, that is, number of tests performed within the 5-years follow-up outside the organized program was described. All models were univariate with separate analyses of the subgroups (SES, mother tongue and municipality type).

The use of the different confidential registries was approved by the National Institute for Health and Welfare (permit no. THL/276/5.05.00/2018) No informed consent was required from the women as data was obtained from the cancer registries. Statistical analyses were performed using the R program (version 3.6.1) (R Core Team, 2019).

3. Results

Altogether 2,484,207 tests were taken during five years among the cohort of 2,298,499 women aged 15–99. Of all tests, 38% were taken within the program and 62% outside it. The average total 5-year coverage in this age range was 62% and 10-year coverage 73%. There was a clear age gradient in the attendance at screening within the organized program and outside of it. Older women of the screening target ages were the most likely to have tests within the program whereas younger women had nonorganized tests. Total coverage was quite high among women below the screening target ages of 30 or 25, due to tests outside the program. However, total coverage decreased steadily by age, particularly after the last organized screen at age 60 or 65. Ten-year coverages followed the same pattern. Also, the number of nonorganized tests was higher, especially among younger age groups (Table 1, Fig. 1).

Characteristics of the study cohort of women within the screening target age range of 30–64 years by socioeconomic status, mother tongue and municipality type are presented in Table 2. For this cohort, altogether 1,880,306 tests were taken, of which 47% within the program and 53% outside it. The average total 5-year test coverage was 86%. The largest SES-categories were lower-level employees, upper-level employees and manual workers. Socioeconomic status was unknown for 3% of the cohort. The largest mother tongue category consisted of the native speakers (Finnish, Swedish and Sami, 94%). Most of the municipalities were of urban type. The organized screening program covered the target population well, since invitations were sent to 99% of the women in our cohort.

Socioeconomic status was associated with test coverage. Attendance rate at the program was highest among lower-level employees (71.9%; 95% CI, (71.7–72.2)), upper-level employees (70.5%; 95% CI, (70.1–70.8)), manual workers (69.5%; 95% CI, (69.1–69.9)) and employers and self-employed (68.2%; 95% CI, (67.6–68.7)) (Fig. 2a, age-adjusted). The most likely groups to have only tests outside the program were students (23%; 95% CI, (22.4–23.5)), those with an unknown socioeconomic status (21.1%; 95% CI, (20.6–21.6)) and upper-level employees (20.6%; 95% CI, (20.4–20.8)) (Fig. 2b, no age adjusted). However, if age was adjusted for, these differences diminished substantially for students and pensioners (Fig. 2b, age adjusted). The least

Table 1
Five and ten-year test coverages of women aged 15–99 by 5-year age groups. Five-year coverages: women residing in Finland in 2010–2014; Ten-year coverages: women residing in Finland in 2005–2014.

Age	N		%							
	All		Attended only organized screening		Attended both organized and nonorganized		Attended only nonorganized tests		No tests	
	Coverage interval									
	5	10	5	10	5	10	5	10	5	10
All	2,298,499	2,291,876	21.0	17.2	17.6	33.6	23.2	22.4	38.2	26.8
15–19	133,372	132,011	0.0	0.0	0.0	0.0	7.1	7.2	92.9	92.8
20–24	130,479	128,947	0.0	0.0	0.0	0.1	50.6	53.7	49.3	46.2
25–29	146,546	144,031	7.7	4.5	9.4	13.2	56.7	65.3	26.2	17.0
30–34	171,114	170,915	22.4	10.1	32.5	49.4	30.3	32.3	14.8	8.2
35–39	170,126	170,021	24.9	14.3	34.2	59.2	26.0	19.4	14.9	7.1
40–44	157,171	157,089	29.9	18.1	34.8	59.7	20.3	14.4	15.0	7.8
45–49	181,412	181,332	34.4	22.5	33.3	57.2	16.9	11.9	15.4	8.3
50–54	189,776	189,697	40.8	27.6	31.3	55.1	12.8	9.1	15.1	8.2
55–59	188,867	188,807	47.3	34.4	26.8	49.7	10.0	7.3	15.8	8.6
60–64	193,341	193,321	52.7	41.0	23.0	44.0	7.7	5.6	16.5	9.4
65–69	198,155	198,031	6.9	37.0	3.7	38.5	31.7	9.9	57.7	14.6
70–74	131,668	131,526	0.1	5.8	0.1	5.8	31.6	40.5	68.2	47.9
75–79	115,914	115,758	0.0	0.1	0.0	0.1	25.1	40.3	74.9	59.5
80–84	90,599	90,502	0.0	0.0	0.0	0.0	16.5	30.7	83.5	69.3
85–89	64,748	64,695	0.0	0.0	0.0	0.0	10.1	21.3	89.9	78.7
90–94	29,218	29,201	0.0	0.0	0.0	0.0	5.8	13.5	94.2	86.5
95–99	5993	5992	0.0	0.0	0.0	0.0	3.3	8.9	96.7	91.1

likely groups to have any tests – within or outside the program – during the five years were those with an unknown socioeconomic status (68.8%; 95% CI, (67.9–69.6)), pensioners (77.1%; 95% CI, (76.5–77.6)), students (80.2%; 95% CI, (79.2–81.2)) and unemployed women (81.3%; 95% CI, (80.8–81.9)) (Fig. 2c, age-adjusted). To note, the student group here comprised of women aged 30 or more, and thus did not represent the general student population.

There were also differences in coverages between mother tongue categories. Attendance at the program was the highest among native speakers (68.9%; 95% CI, (68.7–69.0)). Other language groups attended less actively, but the most active were the Russians (65.6%; 95% CI, (64.6–66.7)) and Thais (62.9%; 95% CI, (60.4–65.4)) (Fig. 3a, age-adjusted). Somali-speaking women were the most likely to have only tests taken outside the program (24.3%; 95% CI, (22.5–26.2)) (Fig. 3b, age-adjusted). On the other hand, they were the least likely to attend for the organized program and to have any tests during the five years (58.1%; 95% CI, (54.9–61.5)) (Fig. 3c, age-adjusted). Non-native speakers were generally younger than the rest of the population (Table 2). Therefore, unadjusted attendance rates of non-native speakers were lower at the organized program and higher at the non-organized tests, compared to age-adjusted estimates.

When comparing different municipality types, women living in urban municipalities were the least likely to attend the program (67.4%; 95% CI, (67.2–67.6)) (Fig. 4a). On the other hand, they were the most likely to have tests taken only outside the program (16.1%; 95% CI, (16.0–16.2)), although the age-adjusted difference to women living in semi-urban municipalities was small (Fig. 4b). The total coverage was highest in semi-urban municipalities (87.4%; 95% CI, (87.0–87.8)) where attendance at both, program tests and non-organized tests, was active (Fig. 4c, age-adjusted). The average age in urban municipalities was lower than in semi-urban or rural municipalities, and therefore age-adjustment reduced the coverage differences

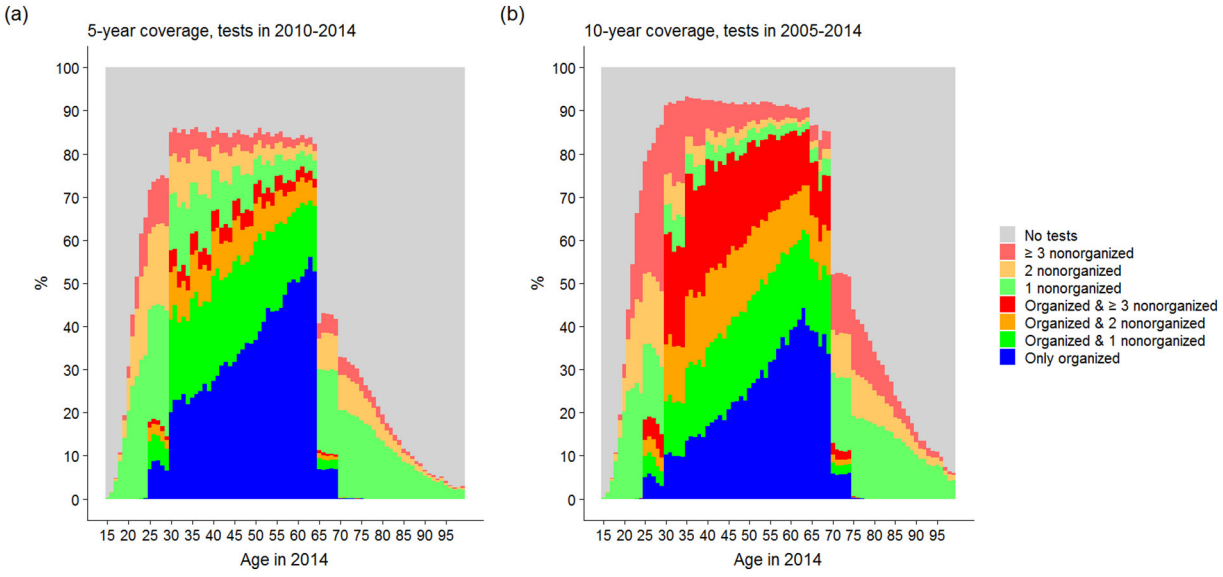

Fig. 1. Five (a) and Ten (b) - year coverages (%) and number of tests taken within and outside the screening program by age.

Table 2
Characteristics and five-year tests coverages of the study cohort by socioeconomic status, mother tongue and municipality type. Women aged 30–64, residing in Finland in 2010–2014.

		Age	Invited to organized screening	Attended only organized screening	Attended both organized and nonorganized	Attended only nonorganized tests	No tests
	N (%)	Mean (sd)	%[a]				
All	1,227,459 (100)	47.6 (10.2)	98.8	37.3	31.2	17.5	14.0
Socioeconomic status							
Upper-level employees	225,780 (18.4)	45.9 (9.5)	98.8	32.5	36.8	20.6	10.1
Lower-level employees	486,426 (39.6)	47.0 (9.9)	99.2	37.9	33.7	17.6	10.9
Employers & self-employed	80,270 (6.5)	48.2 (9.5)	99.1	38.0	30.7	18.2	13.2
Manual workers	163,426 (13.3)	47.8 (10.1)	99.1	43.0	26.7	14.4	15.8
Unemployed	109,586 (8.9)	48.6 (10.7)	98.8	38.6	26.4	16.3	18.7
Students	30,411 (2.5)	39.5 (8.2)	96.8	30.5	27.0	23.0	19.5
Pensioners	96,616 (7.9)	55.9 (8.7)	98.7	39.9	24.1	12.8	23.1
Unknown/others	34,944 (2.8)	44.9 (10.2)	94.5	26.4	21.4	21.1	31.2
Mother tongue							
Finnish/Sami	1,098,410 (89.5)	47.8 (10.2)	99.1	37.6	31.8	17.5	13.1
Swedish	57,476 (4.7)	47.8 (10.1)	99	39.2	29.0	17.4	14.4
Russian	22,352 (1.8)	46.1 (9.7)	98.2	38.9	26.1	14.8	20.2
Estonian	11,079 (0.9)	45.5 (9.7)	96.1	33.2	21.2	16.7	29.0
Thai	4144 (0.3)	41.5 (7.5)	98.2	39.2	20.3	14.8	25.7
Chinese	2663 (0.2)	41.2 (8.5)	96.1	28.5	21.6	15.9	33.9
English	2478 (0.2)	42.3 (9.1)	93.7	23.4	20.2	21.5	34.8
Somali	2049 (0.2)	41.7 (8.4)	93.3	10.4	14.6	33.5	41.4
Other	26,808 (2.2)	41.6 (8.8)	91.2	26.6	23.8	19.6	30.1
Municipality type							
Urban	860,165 (70.1)	47.1 (10.2)	98.7	35.6	31.8	18.1	14.4
Semi-urban	196,348 (16)	48.3 (10.0)	99.1	39.6	30.8	16.9	12.7
Rural	170,946 (13.9)	49.2 (9.8)	99.1	43.1	28.8	14.9	13.2

[a] Denominator: All women regardless of invitation to screening program.

between urban municipalities and others, when looking separately at the organized screening and only nonorganized testing.

The numbers behind Figs. 2–4 are also presented in Supplement Table 1. Average number of tests outside the program per woman by SES, mother tongue and municipality type are presented in Supplement Fig. 1a–c. Upper-level employees, native speakers and women living in urban municipalities were the most likely to have more than one test taken outside the screening program during the five years.

SES, mother tongue and municipality type were also associated with each other (see Supplement Table 2).

4. Discussion

The cervical test coverage among the screening target aged women increased from about 70% with only organized tests up to 86% with all tests. There were differences by age, socioeconomic status, ethnic origin and municipality type in both organized and nonorganized test coverages. Older age was strongly associated with higher attendance at the organized screening program. In addition, women with good access to health services – namely women in the working life – were more likely to attend the program compared to other socioeconomic groups. The program tests were also clearly more popular among native-speaking women compared to other language groups, and among women living in semi-urban or rural municipalities, compared to those living in urban municipalities.

Tests outside the program were extremely common: 62% of all tests were nonorganized. Especially young women, even those clearly below the national screening target ages, were frequently tested. When looking at socioeconomic status, tests outside the program did not seem to narrow down differences detected in the program coverage. Quite the contrary, women in the highest socioeconomic groups were the most likely to have tests both within and outside the program. For some language groups, however, such as the Somali-speaking women, taking into account the nonorganized tests reduced the coverage difference to native speakers. Municipality type differences in the overall test coverage were smaller compared to those detected with SES and mother tongue. Tests outside the program were most common among women living in urban municipalities.

Similar differences in the participation rate and coverage across socioeconomic status have been demonstrated in other countries, particularly in those with opportunistic screening programs, but also to some extent in countries with population-based screening programs (Gianino et al., 2018; Walsh et al., 2011; Palència et al., 2010; Van Leeuwen et al., 2005). This study showed that in the Finnish setting, the presence of nonorganized testing mostly further increased these differences, rather than diminished them.

A lower likelihood of screening participation among immigrant groups compared with the general population have also been demonstrated in other studies, although large variation generally exists between immigrant groups, for example by ethnic background and years spent in the new home country (Azerkan et al., 2012; McDonald and Kennedy, 2007; Idehen et al., 2018). Our results showed large differences between mother tongue groups. Nevertheless, all non-native language groups had lower test coverages compared to the native speaking women.

In this study, we were able for the first time to assess the total

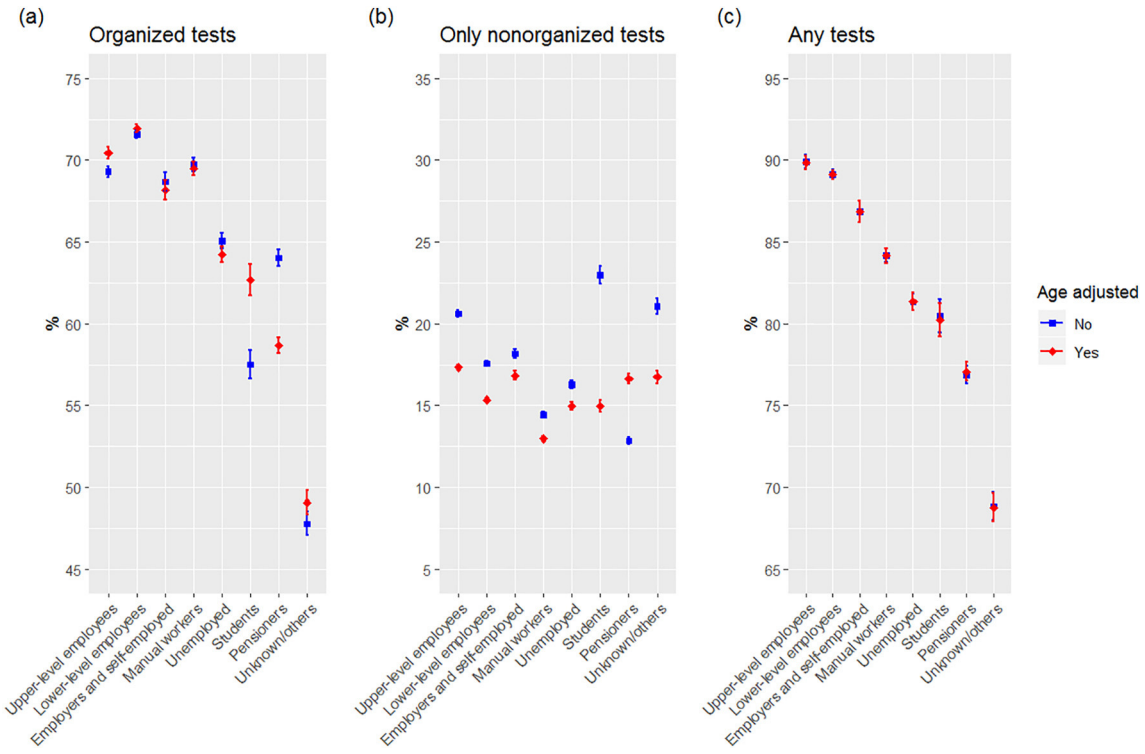

Fig. 2. Percentages and 95% confidence intervals comparing socioeconomic groups with respect to attendance at (a) organized screening, (b) only nonorganized testing and (c) any testing. Both crude and age-adjusted estimates. Note: y-axis scales differ between graphs.

coverage of cervical testing – including nonorganized tests – for the whole Finnish female population within the studied age groups. An earlier study by Salo et al. (2014) from 2004 to 2008 in the capital region showed similar results to ours on the age distribution of the nonorganized tests. In addition, we had comprehensive data on socioeconomic status and mother tongue, representative of the total female population aged 30–64 in 2014 (Statistics Finland, n.d.-a; Statistics Finland, n.d.-b). With individual-level registry data and several years of follow-up, our research data could be considered reliable and extensive.

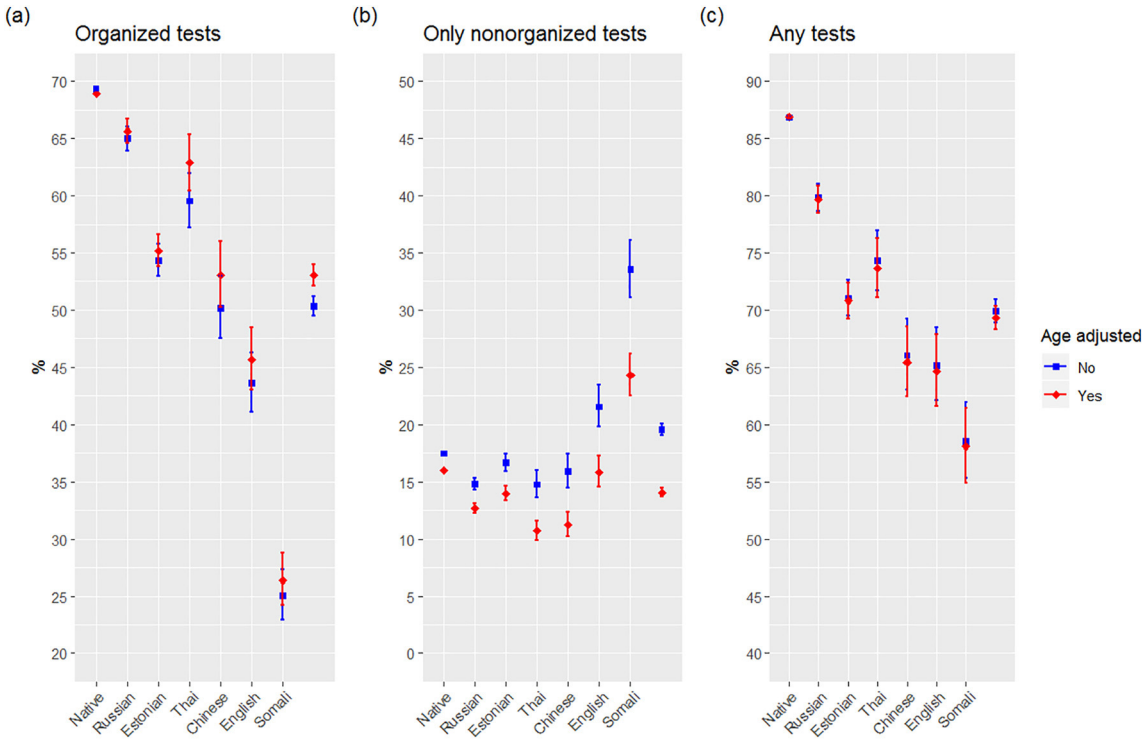

Fig. 3. Percentages and 95% confidence intervals comparing native and non-native speakers with respect to attendance at (a) organized screening, (b) only non-organized testing and (c) any testing. Both crude and age-adjusted estimates. Note: y-axis scales differ between graphs.

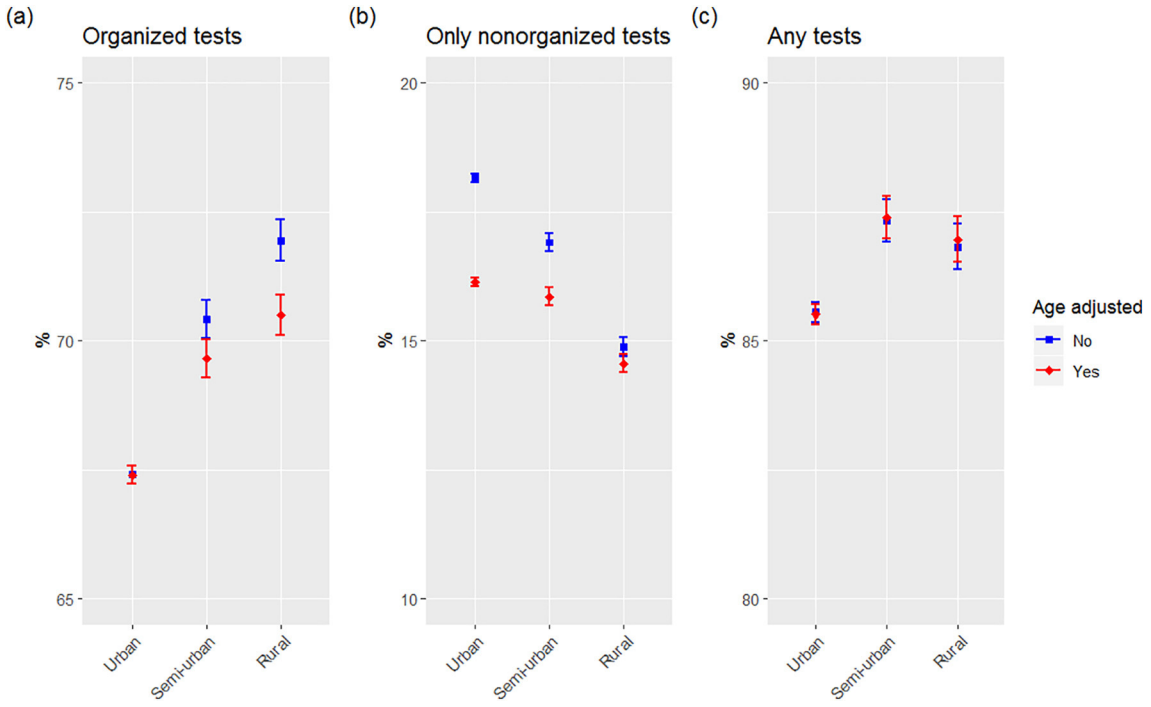

Fig. 4. Percentages and 95% confidence intervals comparing municipality types with respect to attendance at organized screening at (a) organized screening, (b) only nonorganized testing and (c) any testing. Both crude and age-adjusted estimates. Note: y-axis scales differ between graphs.

Our data included over 99% of the tests within the organized screening program during the study period (Finnish Cancer Registry, 2018). However, we might have lacked some of the nonorganized tests. A few laboratories were closed during the follow-up period and therefore could no longer deliver data. All HPV-tests from the organized program were included in our data, but some occasional HPV-tests performed outside the program could be missing. Although HPV-screening was implemented in Finland only since 2012 in a few restricted areas (Finnish Cancer Registry, 2018), these shortages could have led to a slight underestimation of the total coverage and number of tests. However, we were safe to assume to have almost complete data on the nonorganized tests over the study period.

Unfortunately, we did not have comprehensive information on the various dimensions of socio-economic status such as education and income, and thus we only used occupational level as an indicator of SES. Employers and self-employed were categorized together, which made the group quite heterogenous and thus somewhat hard to interpret.

Younger women, some language groups and women living in urban municipalities seemed to compensate their low attendance at the program to a limited degree by tests outside the program. A reason for the popularity of nonorganized tests among these women might be that Pap testing is actively offered as they visit their GP for other purposes. Motivation to attend the organized program might be low, if the tests were recently taken elsewhere. Another reason could be that the tests offered in the private health care are very easily accessible for the most privileged women with good access to health services. If this would be the case, it would seem evident that nonorganized testing would lower the attendance at the program.

The reason why the organized program does not reach some of the ethnic minorities could be found in language barriers, poor access to health care, gaps in knowledge about cancer screening, cultural sensitivity issues, as well as distrust to the host country's health care system (Azerkan et al., 2012; Ghebre et al., 2015; Marlow et al., 2015; Leinonen et al., 2017; Gele et al., 2017). Currently, the invitation to screening is sent by a written letter only in Finnish or Swedish. Tests outside the program, on the other hand, might be offered to them alongside other health care visits, such as maternal health care, which has excellent reach in Finland (Perinatal statistics: parturients, deliveries and newborns 2018 (In Finnish), 2019).

There have been many attempts to remove barriers of screening among immigrant populations. These could be for example better involvement of primary care physicians in promoting the organized program and tailored materials to different language groups (Spadea et al., 2010). A newer method would be offering HPV-self-sampling as an option to attend for the screening program (Virtanen et al., 2015).

Nonorganized testing was the most common in urban municipalities, whereas women in rural municipalities were more likely to have organized tests. Better availability of both public and private health services in urban areas might be the reason for this difference. Also, the organized sample-collecting health care centers cover well the rural areas of Finland.

Women with lower socioeconomic status, as well as some ethnic minorities and women living in urban areas, have an increased risk of invasive cervical cancer, and therefore they would benefit screening the most (Parikh et al., 2003; Arnold et al., 2010; Sharp et al., 2014). According to our results, these were the women who had the lowest total test coverages. Also, our results showed that the total test coverage among older women passing the screening upper age of 60 decreased rapidly, when also nonorganized testing got less frequent. In terms of mortality reduction, however, screening older women after the age of 60 or even 65 would be effective (Lönnberg et al., 2012; Pankakoski et al., 2019; Castañón et al., 2014), whereas most studies have not reported any effectiveness of screening women below the age of 25 (Lönnberg et al., 2012; Makkonen et al., 2017; Zappa et al., 2004). Nevertheless, the total 5-year coverage in our cohort was clearly higher among women aged 20–24 compared to women aged 65–69.

Although cytological abnormalities and pre-cancers are the most prevalent in younger women, they are likely to heal spontaneously (Schlecht et al., 2003). It is noteworthy that in previous decades the Finnish guidelines have recommended to start screening soon after the onset of sexual life (Nieminen et al., 2006). There may also have been similar recommendations in other countries prepared e.g. for contraceptive and maternal health clinics. This could have led to a culture of

excessive testing over the years. Guidelines concerning the screening of young women have later changed since the first edition of the Finnish Current Care Guidelines for cervical precancers: The most recent version states that no Pap testing should occur at all below age 20 and that testing at ages 20–24 should be done only based on clinical indication (Cytological changes in the cervix, vagina and vulva. Current Care Guidelines (In Finnish), 2019).

According to the current guidelines, opportunistic screening is only necessary if a woman has not attended the organized program during the last five years. Testing outside the program is also recommended for women above the screening ages if they have been treated with precancers earlier (Cytological changes in the cervix, vagina and vulva. Current Care Guidelines (In Finnish), 2019). Previous studies have stated that nonorganized testing does not have additional effect in preventing cancer incidence and mortality, after taking into account only tests within the organized program (Makkonen et al., 2017; Nieminen et al., 1999). Since the unit cost of an organized screening test is less expensive than that of a nonorganized test (Salo et al., 2013), shifting emphasis to the organized program from opportunistic testing would be desirable also from a health economic perspective. In the future, our research data should further be used to study the effects of all testing on cancer incidence and mortality.

Retraining the health care staff and raising awareness of adequate screening intervals in the public could be ways to limit over-testing in the future. Currently, surveys targeted to both women and health care professionals are planned to better address this issue. In addition, a unified registry of all tests, organized and opportunistic, would make it easier to remove the overlaps.

5. Conclusion

Our study showed that the average cervical test coverage was high, but attendance at both, organized and nonorganized testing, varied between the subpopulations. Nonorganized testing did not reduce social inequalities, except in the case of some of the small ethnic minorities. In fact, tests outside the program concentrated largely on young women with a low risk of invasive cancer, and on women with high socioeconomic status. In order to improve cost-effectiveness, all women should be encouraged by health care professionals to attend the organized program whenever they are invited. Cutting down the excessive nonorganized testing would reduce adverse effects of screening and save costs. Efforts should be made by the screening program to reach the more deprived women, for example by materials individually tailored to ethnic minorities. Improving the program coverage among these women would be an important way of decreasing the overall cervical cancer incidence and mortality.

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CRediT authorship contribution statement

Maiju Pankakoski: Methodology, Formal analysis, Investigation, Data curation, Writing - original draft, Visualization. **Sirpa Heinävaara:** Conceptualization, Methodology, Data curation, Writing - review & editing, Supervision. **Ahti Anttila:** Conceptualization, Methodology, Data curation, Writing - review & editing, Supervision. **Tytti Sarkeala:** Conceptualization, Methodology, Investigation, Writing - review & editing, Project administration.

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