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Original Contribution

Prostate Cancer and Socioeconomic Status in the Finnish Randomized Study of Screening for Prostate Cancer

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Prostate cancer (PC) screening remains controversial. We investigated whether screening reduces the difference in prostate cancer risk by socioeconomic status (SES). In 1996–2011, a total of 72,139 men from the Finnish Randomized Study of Screening for Prostate Cancer were analyzed. Outcome measures were PC incidence, mortality, and participation in screening. SES indicators were educational level, income, and home ownership status (data obtained from the Statistics Finland registry). The mean duration of follow-up was 12.7 years. Higher SES was associated with a higher incidence of low- to moderate-risk PC but with a lower risk of advanced PC. Higher education was associated with significantly lower PC mortality in both control and screening arms (risk ratio = 0.48–0.69; $P < 0.05$). Higher income was also associated with lower PC mortality but only in the control arm (risk ratio = 0.45–0.73; $P < 0.05$). There were no significant differences in SES gradient by arm ($P_{interaction} = 0.33$ and $P_{interaction} = 0.47$ for primary vs. secondary education and primary vs. tertiary education, respectively; $P_{interaction} = 0.65$ and $P_{interaction} = 0.09$ for low vs. intermediate income and low vs. high income, respectively; and $P_{interaction} = 0.27$ among home ownership status strata). Substantial gradients by SES in PC incidence and mortality were observed in the control arm. Higher SES was associated with overdiagnosis of low-risk PC and, conversely, lower risk of incurable PC and lower PC mortality. Special attention should be directed toward recruiting men with low SES to participate in population-based cancer screening.

incidence; mass screening; mortality; prostate-specific antigen; prostatic neoplasms; randomized controlled trials; socioeconomic status

Abbreviations: CA, control arm; CI, confidence interval; ERSPC, European Randomized Study of Screening for Prostate Cancer; ICD-10, *International Classification of Diseases, Tenth Revision*; PC, prostate cancer; PSA, prostate-specific antigen; SA, screening arm; SES, socioeconomic status.

Organized screening for prostate cancer (PC) with prostate-specific antigen (PSA) testing remains controversial. Although there is evidence for reduction in PC-specific mortality from the European Randomized Study of Screening for Prostate Cancer (ERSPC) (1), the issues surrounding cost-effectiveness and quality of life require further elucidation (2–5). In contrast to the one-screening-protocol-fits-all approach, individualized risk assessment and subsequent customized screening has been proposed (5, 6), but current understanding of the screening effects is insufficient for such customized screening protocols.

In order to optimize cancer screening, the impact of not only biological determinants but also socioeconomic characteristics should be understood, because the latter are likely to influence screening uptake and the balance between harms and benefits of screening. There is vast evidence showing that lower socioeconomic position (e.g., according to education and income) is associated with poorer health and increased mortality from, for example, cancer (7). However, men with high socioeconomic status (SES) have a higher incidence of PC than men with low SES (8–13). This is most likely due to differential behavior in seeking medical

attention and specifically PSA testing (9, 10, 14–16). However, PC mortality does not show a similar gradient, and PC survival is poorer among men with lower SES (17–19). Men with low SES may have lower health literacy and awareness, and they may perceive cancer screening tests as more threatening, more difficult to accomplish, and less beneficial (20). In addition, the potential role of poorer nutrition in the progression of cancer and cancer mortality remains inconclusive (21). Population-based screening has potential to reduce SES differences through provision of uniform preventive health-care services. Therefore, men with low SES, who have higher PC-specific mortality than men with high SES, may be a high-priority target group for PC screening (22–24).

Although SES is a delicate and complex issue that defies compression into few variables, simple proxy variables are needed for exploration of the issue. Relevant proxies include educational level, income, and home ownership status.

Education is a fundamental component of SES; it influences available material resources (including income), cognitive skills, and behavior (e.g., utilization of health services)—and also future employment and income. Men with a high level of education receive more PSA testing, have higher PC incidence, and have lower PC mortality than their less-educated peers (13, 14, 22, 25, 26). Income and housing tenure status serve as proxies for material resources that may influence health. Even in Finland—with universal, inexpensive public health services—all-cause mortality has been reported to be substantially higher for renters than for owner-occupiers, even after adjusting for income, occupation, and education (27).

We investigated how SES affects PC screening outcomes in a large, randomized population-based trial in Finland. In this trial, the control arm (CA) represented how SES is associated with PC incidence and mortality in the general population. A comparison with the screening arm (SA) showed how organized screening affects SES differences. We also investigated whether participation in screening is affected by SES. Our hypothesis was that organized screening may reduce the aforementioned differences in PC incidence and mortality—that is, individually inviting low-SES men to participate in PC screening may reduce their incidence of advanced PC and PC mortality.

The setting was exceptional; we were able to obtain individual-level SES data from extensive Finnish registries, thus avoiding the shortcomings of studies' relying on questionnaires or crude area-based estimates of SES. To our knowledge, this is the first comprehensive study to have analyzed the association between SES and PC-screening outcomes (not merely screening uptake) in a randomized setting.

METHODS

The Finnish Randomized Study of Screening for Prostate Cancer is the largest component of the ERSPC trial; 80,144 men participate in the Finnish trial. The men were born in 1929–1944 (aged 55–67 years at entry) and were identified from the Finnish Population Register. A random sample of 8,000 men was allocated to the SA annually in 1996–1999, and the remaining men in each age group formed the CA, members of which were not contacted and received no intervention.

The screening protocol has been described in detail previously (28). To summarize, the men in the SA were invited to a local clinic for the screening test: determination of serum PSA concentration. Men with a PSA of at least 4.0 ng/mL were referred to a urological clinic for diagnostic examinations including digital rectal examination, transrectal ultrasound, and prostate biopsy. Men with PSA levels of 3.0–3.99 ng/mL were referred for an additional test, which in 1996–1998 was digital rectal examination and since 1999 has been determination of the free PSA:total PSA ratio, with a cutoff point of 16%. Men with a suspicious digital rectal examination or free:total PSA ratio less than 16% were referred for diagnostic examinations similar to those with PSA of at least 4.0 ng/mL. Due to administrative issues, 1,493 men who were randomized to the SA never received an invitation and thus never participated in the screening protocol. These men were still included in the SA.

The men in the SA were invited to the second and third screening rounds in a similar manner 4 and 8 years after the first screening, regardless of previous participation (although not after age 71). Information on cancers detected outside of the screening protocol (interval cancers, cancers in nonparticipants, and cancers in the CA) was obtained from the Finnish Cancer Registry, a nationwide, population-based registry which has 99% coverage of all solid cancers diagnosed in Finland (29).

Cancers were classified according to tumor-node-metastasis staging and Gleason score. Low-risk cancers were T1–2 and N0 or Nx and M0 with a Gleason score of 6 or lower; moderate-risk cancers were T1–2 and N0 or Nx and M0 with a Gleason score of 7 or T3 with a Gleason score of 6. High-risk cancers were T1–3 and N0 or Nx and M0 with Gleason score of 8 or higher or T3 and Gleason score of 7. Finally, advanced PCs were all T4 or any T stage with N1 or M1.

Follow-up ended at death (from any cause), emigration from Finland, or the common closing date (December 31, 2011). In Finland, all deaths are registered in the causes-of-death registry by Statistics Finland, and the *International Classification of Diseases, Tenth Revision* (ICD-10), has been used for this purpose since 1996. Men with PC (code C61 in ICD-10) given as the underlying cause of death in the official causes-of-death registry were defined as having PC deaths. To validate the causes of death in our screening study, all deaths occurring in 1996–2003 among men diagnosed with PC (regardless of randomization arm) were reviewed by a cause-of-death committee. Excellent agreement (97.7%; $\kappa = 0.95$) was shown between the official causes-of-death registry and the cause-of-death committee (30).

Information on socioeconomic factors was obtained from Statistics Finland, which provided socioeconomic register data for 72,139 men, (90.0% of all men in the trial). The remaining 10.0% were omitted from linkage for personal data–protection purposes. Individual, annual data on personal taxable total gross income, educational level, and home ownership status were all linked to the trial database.

Unequivocal linkage was possible using the unique personal identification number that has been assigned to each Finnish citizen since September 1964. SES was based on information for the year preceding randomization into the trial.

Annual income (consisting of all individual taxable income) was categorized into 3 groups. The lowest level of income consisted of men with an annual gross income less than €15,000 (approximately $16,700); the intermediate level was €15,000–€29,999 (approximately $16,700–$33,400); and the highest income level was €30,000 or more. For reference, the median gross income in 2005 was €17,499 (approximately $19,600) for men aged more than 60 years in Finland (31).

Level of education was categorized according to the United Nations' 2011 International Standard Classification of Education into 3 groups: primary education (level 1–2), secondary education (level 3–4), and tertiary education (level 5–8) (32). Because Statistics Finland records information only on completed academic degrees, men with missing information on education were assumed to have had only a primary education.

Home ownership was categorized into 2 groups: those who owned their house or apartment and those who rented their dwelling or had other tenure status (e.g., life annuity or right-of-occupancy dwelling). This information was available for 99% of men.

Helsinki University Hospital and Tampere University Hospital ethics committees approved the study protocol. Permission to use cancer registry data was obtained from the Research and Development Centre for Welfare and Health (currently part of the National Institute of Health and Welfare). The ERSPC trial was registered (http://www.isrctn.com/).

Socioeconomic differences in PC-specific mortality and all-cause mortality were estimated with Poisson regression, taking into account individual follow-up time (using the offset function of the natural logarithm of follow-up time). The SES variables and participation were not fitted to the same model due to collinearity (the variables represent different aspects of SES). The influence of SES on participation and PC risk was analyzed with logistic regression (with individual follow-up time). Statistical analyses were performed with Stata, version 10 (StataCorp LP, College Station, Texas). All statistical tests were 2-sided. A P value below 0.05 was considered statistically significant, and 95% confidence intervals were used in all analyses.

RESULTS

In this subset of the Finnish Randomized Study of Screening for Prostate Cancer, there were 72,139 participants, of whom 28,678 (39.8%) were in the SA, and 43,461 (60.2%) were in the CA. The cumulative incidence of PC was 10.0% in the SA (n = 2,882) and 8.1% in the CA (n = 3,539), yielding a risk ratio of 1.26 (95% confidence interval (CI): 1.20, 1.32; $P < 0.0001$). Mean follow-up in incidence analyses was 12.1 years in both arms of the study.

In the SA, a total of 7,738 (cumulative mortality, 27.0%) men died during follow-up, and 192 (0.67%) of the deaths were due to PC. Corresponding numbers for the CA were 11,604 (26.7%) and 332 (0.76%), which represents a risk ratio for overall death of 0.99 (95% CI: 0.96, 1.02; $P = 0.504$) and a risk ratio for PC death of 0.88 (95% CI: 0.73, 1.05; $P = 0.143$) between trial arms. The mean duration of follow-up in mortality analyses was 12.7 years in both study arms.

Due to the randomized design of the trial, no statistically significant differences were observed in the distribution of SES characteristics between trial arms (Table 1). Of the men who were invited to participate at least once (n = 27,191), 78.8% (n = 21,412) participated at least once. Men with a higher SES were more likely to participate in screening than were men with a lower SES, according to all SES indicators (Table 2).

In the CA, having the highest levels of education and income and being an owner-occupier were associated with increased incidence of low-risk PC. In contrast, incidence of advanced PC was significantly lower among men with secondary or tertiary education than among men with primary education, and also among men with moderate-to-high income compared with those in the lowest income group. Being an owner-occupier or being at the intermediate or highest level of income were associated with having moderate-risk PC, and being an owner-occupier was associated with having high-risk PC (Tables 3–5).

In the SA, the associations were similar to those in the CA regarding low-risk PC. With moderate-risk PC, home ownership status was no longer associated with higher risk (in contrast to the experience in the CA), and neither was having the highest income compared with having a low income (Tables 3–5). The risk of advanced PC was significantly lower for owner-occupiers in the SA compared with renters (in contrast to CA) but, conversely, the marked differences in the risk of advanced PC by income (observed in the CA) were nonsignificant in the SA. Risk of advanced PC remained similar in the SA compared with the CA when education was analyzed. In contrast to the CA, there was not a statistically significant difference between owner-occupiers and renters in the risk of high-risk PC in the SA.

Screening was associated with a higher risk of low-risk PC in all SES groups, by 58%–80% (Tables 3–5), but it was not associated with the risk of moderate-risk PC. Screening was associated with a lower incidence of high-risk PC among the men with the highest educational level, among the men with high income, and among owner-occupiers. The risk of advanced PC was significantly lower in the SA among the lower educational and income levels and among owner-occupiers.

In the CA, PC mortality was significantly lower in men with moderate or high income compared with men in the lowest income group (Tables 6–8). A similar association was observed in men with secondary or tertiary education compared with those who had only primary education. An identical situation was observed in the SA, in which PC mortality was lower with higher SES (the only exception was among men with the highest income vs. the lowest income). Screening did not produce a statistically significant reduction in PC mortality according to any SES indicators, but the most substantial effect was seen in men with

Table 1. Socioeconomic Status Characteristics of Participants in the Control and Screening Arms of the Finnish Randomized Study of Screening for Prostate Cancer, 1996–2011

Socioeconomic Indicator	Control Arm (n = 43,461)		Screening Arm (n = 28,678)	
	No. of Participants	%	No. of Participants	%
Educational level				
Primary	22,884	52.7	15,262	53.2
Secondary	8,192	18.8	5,212	18.2
Tertiary	12,385	28.5	8,204	28.6
Income[a]				
Low-income group	12,732	29.3	8,591	30
Intermediate-income group	15,326	35.3	9,981	34.8
High-income group	11,172	25.7	7,329	25.6
Unknown	4,231	9.7	2,777	9.7
Home ownership status				
Renter or other	10,824	24.9	7,128	24.9
Owner-occupier	32,320	74.4	21,364	74.5
Unknown	317	0.7	186	0.6

[a] The lowest level of income consisted of men with an annual gross income less than €15,000 (approximately $16,700); the intermediate level was €15,000–€29,999 (approximately $16,700–$33,400); and the highest income level was €30,000 or more.

moderate income (risk ratio = 0.75, 95% CI: 0.54, 1.04; P = 0.08) and men with secondary education (risk ratio = 0.68, 95% CI: 0.43, 1.08; P = 0.10) (Tables 6–8). The men in the lowest SES group had significantly higher all-cause mortality compared with men who had at least a secondary education, had at least moderate income, or were owner-occupiers (Tables 9–11).

There was no interaction present between any SES indicator and trial arm (Tables 3–11).

DISCUSSION

High SES was associated with increased incidence of low- to moderate-risk cancers in the CA of the study,

Table 2. Impact of Socioeconomic Status on Participation in a Prostate Cancer Screening Program, Finnish Randomized Study of Screening for Prostate Cancer, 1996–2011[a]

Socioeconomic Indicator	Level of Participation		OR	95% CI
	No. of Participants	%		
Educational level				
Primary	10,434	72.8	1	
Secondary	4,162	83.5	1.89	1.74, 2.06[b]
Tertiary	6,816	86.5	2.4	2.23, 2.58[b]
Income[c]				
Low-income group	5,964	73.1	1	
Intermediate-income group	8,126	85	2.08	1.93, 2.24[b]
High-income group	6,114	86.7	2.39	2.20, 2.60[b]
Home ownership				
Renter or other	4,273	64.8	1	
Owner-occupier	17,074	83.5	2.75	2.58, 2.93[b]

Abbreviations: CI, confidence interval; OR, odds ratio.
[a] Logistic regression with offset function.
[b] $P < 0.0001$.
[c] The lowest level of income consisted of men with an annual gross income less than €15,000 (approximately $16,700); the intermediate level was €15,000–€29,999 (approximately $16,700–$33,400); and the highest income level was €30,000 or more.

Table 3. Associations[a] Between Educational Level and Prostate Cancer Incidence by Trial Arm, Finnish Randomized Study of Screening for Prostate Cancer, 1996–2011

Prostate Cancer Risk and Trial Arm	Educational Level												Primary vs. Secondary			Primary vs. Tertiary		
	Primary				Secondary				Tertiary									
	No.[b]	%	OR	95% CI	No.	%	OR	95% CI	No.	%	OR	95% CI	OR	95% CI	*P* Value	OR	95% CI	*P* Value
Low-risk PC			1.73	1.56, 1.92			1.58	1.34, 1.85			1.80	1.60, 2.03						
CA	714	3.1			319	3.9			532	4.3			1.07	0.94, 1.22	0.325	1.17	1.04, 1.31	0.008
SA	789	5.2			307	5.9			600	7.3			0.98	0.85, 1.12	0.725	1.22	1.09, 1.36	<0.0001
P value	<0.0001				<0.0001				<0.0001									
$P_{interaction}$													0.34			0.61		
Moderate-risk PC			1.02	0.88, 1.18			1.18	0.95, 1.48			1.07	0.90, 1.28						
CA	458	2.0			186	2.3			321	2.6			0.97	0.82, 1.15	0.717	1.09	0.95, 1.26	0.221
SA	307	2.0			137	2.6			223	2.7			1.12	0.92, 1.38	0.267	1.15	0.97, 1.37	0.117
P value	0.766				0.137				0.416									
$P_{interaction}$													0.28			0.67		
High-risk PC			0.84	0.69, 1.01			0.92	0.69, 1.22			0.73	0.57, 0.94						
CA	311	1.4			131	1.6			197	1.6			1.0	0.82, 1.23	0.96	0.99	0.82, 1.18	0.879
SA	171	1.1			75	1.4			94	1.1			1.1	0.84, 1.45	0.491	0.86	0.67, 1.11	0.261
P value	0.062				0.546				0.014									
$P_{interaction}$													0.6			0.41		
Advanced PC			0.75	0.60, 0.95			0.54	0.34, 0.87			0.78	0.51, 1.19						
CA	222	1			68	0.8			65	0.5			0.73	0.55, 0.96	0.023	0.45	0.34, 0.60	<0.0001
SA	110	0.7			23	0.4			33	0.4			0.52	0.33, 0.82	0.005	0.47	0.32, 0.69	<0.0001
P value	0.016				0.011				0.253									
$P_{interaction}$													0.21			0.88		

Abbreviations: CA, control arm; CI, confidence interval; OR, odds ratio; PC, prostate cancer; SA, screening arm.
[a] Logistic regression with offset function.
[b] Number of participants.

Table 4. Associations[a] Between Income Level and Prostate Cancer Incidence by Trial Arm, Finnish Randomized Study of Screening for Prostate Cancer, 1996–2011

Prostate Cancer Risk and Trial Arm	Income Level												Low vs. Intermediate			Low vs. High		
	Low				Intermediate				High									
	No.[b]	%	OR	95% CI	No.	%	OR	95% CI	No.	%	OR	95% CI	OR	95% CI	*P* Value	OR	95% CI	*P* Value
Low-risk PC			1.69	1.48, 1.92			1.77	1.57, 1.98			1.63	1.44, 1.86						
CA	447	3.5			582	3.8			502	4.5			1.05	0.93, 1.20	0.411	1.24	1.09, 1.41	0.001
SA	486	5.7			636	6.4			513	7.0			1.10	0.98, 1.25	0.111	1.20	1.06, 1.37	<0.005
P value	<0.0001				<0.0001				<0.0001									
$P_{interaction}$													0.60			0.74		
Moderate-risk PC			1.07	0.88, 1.29			1.10	0.94, 1.29			1.01	0.84, 1.21						
CA	262	2.1			401	2.6			287	2.6			1.24	1.06, 1.46	0.370	1.20	1.02, 1.43	0.033
SA	185	2.2			281	2.8			186	2.5			1.28	1.06, 1.55	0.010	1.13	0.92, 1.39	0.235
P value	0.489				0.218				0.939									
$P_{interaction}$													0.81			0.66		
High-risk PC			0.87	0.67, 1.10			0.81	0.66, 1.00			0.74	0.57, 0.96						
CA	193	1.5			260	1.7			172	1.5			1.09	0.90, 1.31	0.370	0.97	0.79, 1.20	0.802
SA	111	1.3			135	1.4			82	1.1			1.02	0.79, 1.31	0.884	0.83	0.62, 1.10	0.197
P value	0.238				0.051				0.024									
$P_{interaction}$													0.68			0.37		
Advanced PC			0.65	0.47, 0.89			0.63	0.45, 0.88			1.10	0.73, 1.66						
CA	130	1.0			121	0.8			55	0.5			0.75	0.58, 0.96	0.023	0.46	0.34, 0.63	<0.0001
SA	56	0.7			49	0.5			39	0.5			0.73	0.50, 1.07	0.111	0.78	0.52, 1.18	0.237
P value	0.007				0.007				0.642									
$P_{interaction}$													0.90			0.33		

Abbreviations: CA, control arm; CI, confidence interval; OR, odds ratio; PC, prostate cancer; SA, screening arm.

[a] Logistic regression with offset function.

[b] Number of participants.

Table 5. Associations[a] of Home Ownership Status With Prostate Cancer Incidence by Trial Arm, Finnish Randomized Study of Screening for Prostate Cancer, 1996–2011

Prostate Cancer Risk and Trial Arm	Renters				Owners				Renters vs. Owners		
	No.[b]	%	OR	95% CI	No.	%	OR	95% CI	OR	95% CI	*P* Value
Low-risk PC			1.59	1.35, 1.87			1.75	1.62, 1.89			
CA	297	2.7			1,264	3.9			1.31	1.15, 1.49	<0.0001
SA	301	4.2			1,386	6.5			1.44	1.27, 1.64	<0.0001
P value	<0.0001				<0.0001						
$P_{interaction}$									0.31		
Moderate-risk PC			1.11	0.89, 1.38			1.06	0.95, 1.19			
CA	197	1.8			765	2.4			1.19	1.01, 1.39	0.032
SA	141	2.0			524	2.5			1.14	0.94, 1.37	0.175
P value	0.366				0.313						
$P_{interaction}$									0.73		
High-risk PC			1.01	0.76, 1.34			0.78	0.67, 0.90			
CA	122	1.1			515	1.6			1.29	1.06, 1.58	0.012
SA	80	1.1			260	1.2			0.99	0.77, 1.28	0.952
P value	0.938				0.001						
$P_{interaction}$									0.11		
Advanced PC			0.91	0.64, 1.29			0.67	0.54, 0.84			
CA	85	0.8			266	0.8			0.95	0.75, 1.22	0.702
SA	50	0.7			116	0.5			0.71	0.51, 0.99	0.041
P value	0.583				<0.0001						
$P_{interaction}$									0.16		

[a] Logistic regression with offset function.
[b] Number of participants.

suggesting overdiagnosis, but also with a substantially lower incidence of incurable, advanced PC. When invited to participate in a screening program, men with high SES were significantly more active in participating than were men with low SES. Advanced PC incidence was reduced among the lower educational and income groups and, especially, income level differences decreased in advanced PC incidence and PC mortality in the SA compared with the CA. A very prominent all-cause mortality gradient in each SES stratum was evident in both the CA and the SA.

Despite the recent promising results on mortality in the ERSPC trial, PC screening remains a highly complex and problematic issue due to the adverse effects of such screening (1). Currently it looks doubtful that population-based PC screening will take place unless substantial improvements are made to the sensitivity and specificity of the screening process in order to detect only clinically significant PC (33). With other cancer types—namely breast cancer, cervical cancer, and colorectal cancer—population-based screening is already common practice in many industrialized countries (34).

As stated in the World Health Organization criteria for cancer screening, case-finding should be a continuing process and not a "once and for all" project (35). Therefore, all screening programs must be evaluated and improved constantly, even programs that have been running for decades. In addition to optimizing the screening protocol per se, it is obvious that PC screening is more beneficial in some subgroups of the population than in others.

Attention to SES could potentially help improve screening effectiveness resulting from differential health behavior across SES groups. People who participate in organized screening tend to be healthier and more health-conscious than those who do not participate (36), and this is likely to be true for nonorganized screening as well. Different socioeconomic backgrounds provide for different thresholds for seeking and receiving medical attention, as seen in studies that show lower PC incidence but higher PC mortality in men with low SES (13, 14, 22, 25, 26).

The strength of our study was that we were able to combine a large, prospective, population-based PC screening trial database with the SES register data from Statistics Finland, which reliably collects information on such factors as income taxes, completed academic degrees, and living conditions. Thus, we were able to assess how SES factors affect PC incidence and mortality in the CA and compare that with a population in which organized screening was offered (the SA). To our knowledge, this is the first study that combined data from a large population-based cancer screening trial with national-level register data.

Table 6. Prostate Cancer Mortality[a] According to Educational Level and Trial Arm, Finnish Randomized Study of Screening for Prostate Cancer, 1996–2011

Trial Arm	Educational Level												Primary vs. Secondary			Primary vs. Tertiary		
	Primary				Secondary				Tertiary									
	No.[b]	%	RR	95% CI	No.	%	RR	95% CI	No.	%	RR	95% CI	RR	95% CI	*P* Value	RR	95% CI	*P* Value
CA	208	0.91			60	0.73			64	0.52			0.69	0.52, 0.92	0.010	0.48	0.36, 0.63	<0.0001
SA	122	0.80			26	0.50			44	0.54			0.53	0.35, 0.81	0.004	0.56	0.40, 0.79	0.001
Comparison (SA vs. CA)			0.88	0.70, 1.10			0.68	0.43, 1.08			1.04	0.71, 1.52						
P value	0.253				0.101				0.859									
$P_{interaction}$													0.33			0.47		

Abbreviations: CA, control arm; CI, confidence interval; OR, odds ratio; PC, prostate cancer; SA, screening arm.
[a] Poisson regression.
[b] Number of participants.

Table 7. Prostate Cancer Mortality[a] According to Income Level and Trial Arm, Finnish Randomized Study of Screening for Prostate Cancer, 1996–2011

Trial Arm	Income Level												Low vs. Intermediate			Low vs. High		
	Low				Intermediate				High									
	No.[b]	%	RR	95% CI	No.	%	RR	95% CI	No.	%	RR	95% CI	RR	95% CI	*P* Value	RR	95% CI	*P* Value
CA	120	0.94			109	0.71			50	0.45			0.73	0.56, 0.95	0.017	0.45	0.33, 0.63	<0.0001
SA	67	0.78			53	0.53			42	0.57			0.66	0.46, 0.94	0.023	0.70	0.48, 1.03	0.071
Comparison (SA vs. CA)			0.83	0.61, 1.12			0.75	0.54, 1.04			1.28	0.85, 1.93						
P value	0.213				0.081				0.238									
$P_{interaction}$													0.65			0.09		

Abbreviations: CA, control arm; CI, confidence interval; OR, odds ratio; PC, prostate cancer; SA, screening arm.
[a] Poisson regression.
[b] Number of participants.

Table 8. Prostate Cancer Mortality[a] According to Home Ownership Status and Trial Arm, Finnish Randomized Study of Screening for Prostate Cancer, 1996–2011

Trial Arm	Home Ownership Status								Renters vs. Owners		
	Renters				Owners						
	No.[b]	%	RR	95% CI	No.	%	RR	95% CI	RR	95% CI	*P* Value
CA	69	0.64			260	0.80			1.14	0.87, 1.48	0.349
SA	48	0.67			143	0.67			0.90	0.65, 1.24	0.513
Comparison (SA vs. CA)			1.05	0.73, 1.52			0.83	0.68, 1.02			
P value	0.783				0.077						
$P_{interaction}$									0.27		

Abbreviations: CA, control arm; CI, confidence interval; OR, odds ratio; PC, prostate cancer; SA, screening arm.
[a] Poisson regression.
[b] Number of participants.

In the present study, the CA represented how SES affects PC incidence and mortality in an ethnically homogeneous industrialized nation with a publicly funded health-care system and a relatively low degree of economic inequality on a global scale, as measured by the Gini index (37). Our results from the CA showed a clear association between SES and PC incidence such that a higher SES was associated with a higher risk of low-, moderate-, and high-risk PCs but with a lower risk of advanced, incurable PC. This was mirrored in the lower PC mortality in the men with moderate or high income or at least a secondary-level education. In addition, SES had a very substantial impact on all-cause mortality; higher SES was associated with lower mortality compared with mortality among those who had only primary education, had low income, or were renters.

The men with higher SES were more eager to participate in the screening program, although they most likely also received more opportunistic screening (nonsystematic PSA testing) and medical attention outside the program, which can eliminate the need for participating in an organized screening program. The difference compared with the men in the low-SES group was statistically significant in all categories of SES. Nevertheless, as many as 65%–73% of the men in the lowest SES groups (compared with 87% among the most advantaged men) did participate at least once during the 3 rounds of screening, representing relatively good coverage considering the population-based design of the trial. A lower degree of participation in organized screening among persons with lower SES is an important mediator of the association of SES with incidence and mortality. Previous studies show that low SES results in markedly worse uptake in organized colorectal cancer screening (38) and breast cancer screening (39). Moreover, at least with colorectal cancer, low SES is a risk factor for not undergoing a diagnostic workup after a positive screening test (40). To facilitate participation of low-SES men in organized cancer screening, it may be essential that participation be made inexpensive and convenient, preferably without the need for a separate medical appointment.

Organized screening was associated with a higher risk of low-risk PC in each SES category, by 58%–80%, which is not surprising given the previously reported risks of overdiagnosis with PSA-based PC screening (5, 41). The largest difference in low-risk PC incidence was observed among men with moderate income or tertiary education (80%), who also were keen participants in screening.

Screening did dilute the risk difference for advanced PC by income. If organized screening had a strong diluting effect on the associations between SES groups, especially in high-risk and advanced PC, this would result in increased equality and could be seen as one argument when assessing the usefulness of organized screening (in addition to effects on morbidity, mortality, quality of health, and overall cost-effectiveness). Screening was associated with reduced differences in high-risk PC among owner-occupiers compared with renters, but conversely screening appeared to increase differences in advanced PC incidence by home ownership status.

Screening had no statistically significant association with PC mortality in any SES category; regarding PC mortality, the screening was not particularly effective in any SES subgroup in this analysis, which had less than 13 years of follow-up. Although results were statistically nonsignificant, the largest relative protective associations were seen in men with low or moderate incomes, men with primary or secondary education, and men who were owner-occupiers. It remains to be seen whether the observed reduction in the risk of advanced PC will deliver reduced PC mortality with longer follow-up. So far no prospective, individual-level SES mortality reports have been published for PC, but in a Swedish population-based study of breast cancer (which also used national registries for extracting SES data), there was no difference in breast cancer mortality between SES groups (42). The Swedish study was ecological (not randomized), and the population was restricted to 40- to 49-year-olds (42).

Shortcomings of this study include possibly limited generalizability to other countries with different health-care systems. Nevertheless, in Finland the public health-care system serves those with low SES relatively well, and therefore the observed differences are likely to be greater in countries with more economic inequality. Also, although the Finnish screening trial is larger than, for example, the

Table 9. All-Cause Mortality[a] by Educational Level and Trial Arm, Finnish Randomized Study of Screening for Prostate Cancer, 1996–2011

Trial Arm	Educational Level												Primary vs. Secondary			Primary vs. Tertiary		
	Primary				Secondary				Tertiary									
	No.[b]	%	RR	95% CI	No.	%	RR	95% CI	No.	%	RR	95% CI	RR	95% CI	*P* Value	RR	95% CI	*P* Value
CA	8,541	37.3			1,467	18.3			1,566	12.6			0.42	0.40, 0.44	<0.0001	0.28	0.27, 0.30	<0.0001
SA	5,734	37.6			959	18.4			1,045	12.7			0.42	0.39, 0.45	<0.0001	0.28	0.27, 0.30	<0.0001
Comparison (SA vs. CA)			1.00	0.97, 1.04			1.01	0.93, 1.09			1.04	0.93, 1.09						
P value	0.782				0.879				0.901									
$P_{interaction}$													0.97			1.00		

Abbreviations: CA, control arm; CI, confidence interval; OR, odds ratio; PC, prostate cancer; SA, screening arm.
[a] Poisson regression.
[b] Number of participants.

Table 10. All-Cause Mortality[a] by Income Level and Trial Arm, Finnish Randomized Study of Screening for Prostate Cancer, 1996–2011

Trial Arm	Income Level												Low vs. Intermediate			Low vs. High		
	Low				Intermediate				High									
	No.[b]	%	RR	95% CI	No.	%	RR	95% CI	No.	%	RR	95% CI	RR	95% CI	*P* Value	RR	95% CI	*P* Value
CA	3,700	29.1			2,743	17.9			1,190	10.7			0.60	0.57, 0.63	<0.0001	0.35	0.33, 0.37	<0.0001
SA	2,490	29.0			1,810	18.1			828	11.3			0.61	0.57, 0.64	<0.0001	0.37	0.34, 0.40	<0.0001
Comparison (SA vs. CA)			1.00	0.95, 1.05			1.01	0.95, 1.07			1.06	0.97, 1.16						
P value	0.902				0.676				0.196									
$P_{interaction}$													0.69			0.24		

Abbreviations: CA, control arm; CI, confidence interval; OR, odds ratio; PC, prostate cancer; SA, screening arm.
[a] Poisson regression.
[b] Number of participants.

Table 11. All-Cause Mortality[a] by Home Ownership Status and Trial Arm, Finnish Randomized Study of Screening for Prostate Cancer, 1996–2011

Trial Arm	Home Ownership Status										
	Renters				Owners				Renters vs. Owners		
	No.[b]	%	RR	95% CI	No.	%	RR	95% CI	RR	95% CI	*P* Value
CA	4,241	39.2			7,188	22.2			0.51	0.49, 0.53	<0.0001
SA	2,765	38.8			4,863	22.8			0.53	0.51, 0.55	<0.0001
Comparison (SA vs. CA)			0.99	0.94, 1.04			1.02	0.99, 1.06			
P value	0.595				0.215						
$P_{interaction}$									0.24		

Abbreviations: CA, control arm; CI, confidence interval; OR, odds ratio; PC, prostate cancer; SA, screening arm.
[a] Poisson regression.
[b] Number of participants.

Prostate, Lung, Colorectal, and Ovarian Cancer Screening Trial (43), the number of PC deaths remained low, limiting the power of the trial when assessing mortality by various SES subgroups.

Results from our randomized prospective screening trial with individual-level SES data confirmed the marked differences in PC incidence, PC-specific mortality, and especially all-cause mortality across SES indicators in the absence of organized screening. Organized screening can dilute these differences to a limited extent and decrease particularly the risk of advanced incurable PC in the men with low income. Targeting men with low SES is likely to improve screening effectiveness. With less than 13 years of follow-up, an effect of organized screening on PC mortality was not appreciable in any SES subgroup. Given the long lead time of PC, it is likely that longer follow-up of an additional 5–10 years will produce more substantial differences in PC incidence and mortality.

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