Aging Clinical and Experimental Research (2021) 33:3333–3342
https://doi.org/10.1007/s40520-021-01852-9

ORIGINAL ARTICLE

Neighborhood social capital and incidence and mortality of prostate cancer: a Swedish cohort study

Tsuyoshi Hamano[1,2] · Xinjun Li[3] · Jan Sundquist[2,3,4] · Kristina Sundquist[2,3,4]

Received: 21 January 2021 / Accepted: 30 March 2021 / Published online: 22 April 2021

Abstract

Background There is a growing interest in the contextual effect of neighborhood linking social capital on different health outcomes, including cancer.

Aims To examine associations between neighborhood linking social capital and incidence and mortality of prostate cancer.

Method This cohort study was based on national registers. Between 2002 and 2015, we included 1,196,563 men aged 50 years and above in the analyses. Multilevel logistic regression was used to estimate odds ratios (ORs) and 95% confidence intervals (CI) for the association between exposure and outcome, adjusting for potential confounding factors.

Results The total incidence of prostate cancer and mortality in patients with prostate cancer were 8.22 (per 100) and 1.80 (per 100), respectively, during the follow-up period. Individuals living in neighborhoods with low (OR 0.90; 95% CI 0.88–0.93) and intermediate (OR 0.94; 95% CI 0.92–0.96) linking social capital were less likely to be diagnosed with prostate cancer than those living in neighborhoods with high linking social capital. Opposite effects were observed for mortality; prostate cancer patients living in neighborhoods with low (OR 1.15; 95% CI 1.08–1.23) and intermediate (OR 1.09; 95% CI 1.03–1.14) linking social capital were more likely to die from prostate cancer than those in neighborhoods with high linking social capital.

Conclusions Lower neighborhood linking social capital was associated with lower incidence but higher mortality in patients with prostate cancer. These findings suggest that men living in neighborhoods with low linking social capital may need additional surveillance for prostate cancer.

Keywords Cancer screening · Health disparities · Prostate cancer · Social capital

Introduction

Prostate cancer is a very common type of cancer in the male population. In 2018, the global number of cases and deaths from prostate cancer were 1,276,106 and 358,989, respectively [1]. Although several risk factors for the development and progression of prostate cancer has been identified, such as family history and genetic factors [2], advanced age [2], and ethnicity [2], these factors are not modifiable. Previous studies have also revealed potential modifiable risk factors, such as obesity [3], dietary factors [4], and physical inactivity [5]. Moreover, in recent years, there has been an increasing interest in the contextual (neighborhood) effect on prostate cancer [6, 7].

Neighborhood social capital is considered to be a neighborhood feature that may be modifiable and high neighborhood social capital could thus promote good health [8] and potentially reduce social disparities in prostate cancer. Neighborhood social capital has been frequently operationalized as a collective dimension of society that is external from an individual [8], and it is established through social relationships that can improve the efficiency of society by facilitating coordinated actions [9]. Neighborhood social capital has three perspectives: linking, bonding, and bridging

✉ Tsuyoshi Hamano
thamano@cc.kyoto-su.ac.jp

1 Department of Sports Sociology and Health Sciences, Faculty of Sociology, Kyoto Sangyo University, Motoyama Kamigamo, Kita-ku, Kyoto, Japan

2 Center for Community-Based Health Research and Education (CoHRE), Organization for the Promotion of Project Research, Shimane University, Izumo, Japan

3 Center for Primary Health Care Research, Lund University, Malmö, Sweden

4 Department of Family Medicine and Community Health, Department of Population Health Science and Policy, Icahn School of Medicine At Mount Sinai, New York, NY, USA

social capital [10]. Few studies have examined associations between low neighborhood linking social capital and cancer [11, 12]; in addition, to our knowledge, no large-scale follow-up study has examined the potential effect of neighborhood linking social capital on prostate cancer.

Several studies have suggested potential mechanisms relating neighborhood social capital and individual health: the diffusion of knowledge on health promotion, the maintenance of healthy behavioral norms through informal social control, and psychological processes that provide effective support [8, 13, 14]. Therefore, we hypothesized that lower levels of neighborhood linking social capital may be associated with a greater incidence of prostate cancer among Swedish men aged 50 years and older. Besides, we investigated whether lower levels of neighborhood linking social capital are associated with higher mortality of patients with prostate cancer.

Methods

Data sources

This cohort study started on January 1, 2002 and proceeded until the first event of prostate cancer, death from prostate cancer, death from any other cause, emigration, or the end of the study period on December 31, 2015.

Data used in this study were retrieved from several national registers that contain information on the entire Swedish population. We used datasets containing nationwide individual and neighborhood information, including comprehensive demographic and socioeconomic data. This study used the Total Population Register, the Hospital Discharge Register (1964–2015), the Outpatient Register (2001–2015), the Cancer Register (1958–2015), and the National Registry of Causes of Death (1961–2015); the latter was used to identify the date and cause of death. Individuals were tracked using personal identification numbers, which are assigned to each resident of Sweden. Each personal identification number was replaced with a serial number to ensure the confidentiality of all individuals.

All individuals were geocoded to their neighborhoods of residence for the assessments of linking social capital, and small area market statistics (SAMS) were used to define neighborhoods. The SAMS boundaries, which are small administrative areas in Sweden with an average population of about 1000 residents, were drawn to include similar types of housing construction in a neighborhood. We included 7264 SAMS units in the present study.

We excluded individuals with unknown neighborhood information ($n = 5{,}846$, 0.5%) and who were diagnosed with prostate cancer between January 1, 1999 and December 31, 2001 ($n = 14{,}729$, 1.2%) in order to "wash out" individuals with prevalent prostate cancer. In total, 1,196,563 men aged ≥ 50 years were included in the analyses.

Neighborhood linking social capital

Linking social capital refers to connections between individuals/groups who interact across explicit power or authority gradients in society [10, 13, 15]. A recent review found that linking social capital can be assessed by voting and trust in legal, political, or government institutions [16]. Several studies conducted in Sweden used voting rates in local government elections as a proxy of neighborhood linking social capital [11, 12, 17–19]. Voting during local government elections is believed to be a relatively stable variable over time, and the participation rates in local government elections can be considered a good indicator of neighborhood linking social capital.

Neighborhood linking social capital was conceptualized as the number of people in the neighborhood (SAMS) who voted in local government elections divided by the number of people in the neighborhood who were entitled to vote at baseline (2002). Neighborhoods were divided into the following three groups based on the proportions of residents who voted: (1) low, (2) intermediate, and (3) high. Group 1 comprised 20% of the entire Swedish population living in neighborhoods with the lowest proportions of voters ($\leq 74.0\%$). Group 2 comprised 60% of the entire Swedish population living in neighborhoods with intermediate proportions of voters (74.1–82.0%), and group 3 comprised 20% of the entire Swedish population living in neighborhoods with the highest proportions of voters ($> 82.0\%$).

Outcome variables

The outcome variables in this study were new cases of prostate cancer (yes/no) and deaths in patients with prostate cancer (yes/no), respectively. We used the Swedish Cancer Registry to identify the primary diagnoses of prostate cancer in the study population. This information was then linked to the records in the Cause of Death Register to identify deaths among patients with prostate cancer during the study period. All cancer cases in Sweden must be registered in the Swedish Cancer Registry. The completeness of cancer registration is currently close to 100%. Only primary neoplasms of the prostate classified according to the 7th revision of the International Classification of Diseases (ICD-7) were studied. The Swedish Cancer Registry has transferred all the cancer ICD codes into ICD-7 codes; in this study, code 177 was used. The outcome variable, i.e., mortality due to prostate cancer in the cause of death register was defined according to ICD-10 (codes C61).

Independent variables

The independent variables were age at baseline, marital status, family income, educational attainment, immigration status, geographical region of residence, mobility, diagnosis of chronic obstructive pulmonary disease (COPD) as a proxy for smoking, alcoholism or alcohol-related liver disease, coronary heart disease, hypertension, diabetes, obesity, and tobacco smoking.

Age

The participants were 50 years and older at baseline.

Marital status

Participants were classified as married/cohabiting or single (including divorced and widows/widowers).

Family income

Information on family income in 2002 came from the Total Population Register, which was provided to us by Statistics Sweden. We used this information to determine the distribution of family income in Sweden and then used the distribution to calculate empirical quartiles.

Educational attainment

Participants were classified based on completion of compulsory school or less (≤ 9 years), practical high school or some theoretical high school (10–12 years), or completed theoretical high school and/or college (> 12 years).

Immigration status

Individuals were born in or outside Sweden.

Geographical region of residence

Individuals were classified as living in a large city, Southern Sweden, or Northern Sweden.

Mobility

This variable was defined as the length of time the individuals had lived in the neighborhood, i.e., < 5 or ≥ 5 years).

Comorbidities

Individuals with a history of COPD, which was used as a proxy for smoking, were identified in the Hospital Registry and Outpatient Register during the follow-up period according to the corresponding ICD codes (ICD-10, J40–J49). Individuals with a history of alcoholism or alcohol-related liver disease were identified according to ICD-10, codes F10 and K70. The rest of the comorbidities were identified as follows: coronary heart disease (ICD-10, I20-I25), diabetes (ICD-10, E10-E14), hypertension (ICD-10 I10-I19), obesity (ICD-10, E65-E68), and tobacco smoking (ICD-10, F17, T65.2, Z71.6, Z72.0).

Statistical analyses

Multilevel logistic regression models were used to estimate odds ratios (ORs) with 95% confidence intervals (95% CIs). In this study, multi-level Cox proportional hazards models were not used, because the extensive data set was too large to run on available software. However, multilevel logistic regression models are a good approximation of Cox proportional hazards models under circumstances such as ours, i.e., a large sample size, low incidence, risk ratios of moderate size, and a relatively short follow-up [20]. The analyses were performed using MLwiN version 3.02 (University of Bristol, Bristol, UK). Random intercept multilevel logistic regression models were used to allow for the clustering of individuals within neighborhoods and to estimate the variance in the risk for prostate cancer that is attributable to neighborhood characteristics. This approach was used to estimate the intraclass correlation coefficient (ICC), thereby determining and comparing the proportion of variance in the outcome attributable to the differences between the individuals in different and same neighborhoods [21]. The ICC was estimated using the latent variable method as exemplified by the formula

$$\mathrm{ICC} = \mathrm{V_n}/\left(\mathrm{V_n} + \pi^2/3\right),$$

where $\mathrm{V_n}$ is the variance between neighborhoods and $\pi^2/3$ is the estimated variance between individuals. The proportion of the second-level variance explained by different variables was calculated as

$$\mathrm{V_{EXPLAINED}} = \left(\mathrm{V_0} - \mathrm{V_1}\right)/\mathrm{V_0} \times 100,$$

where $\mathrm{V_0}$ is the second-level variance in the initial model and $\mathrm{V_1}$ is the second-level variance in the different models.

Results

The characteristics of the study participants are presented in Table 1. Among the 1,196,563 Swedish men aged 50 years and older, the cumulative incidence (per 100) and cumulative mortality (per 100) from prostate cancer were 8.22 (95% CI 8.17–8.27) and 1.80 (95% CI 1.78–1-83), respectively, during the follow-up period.

Table 1 Distribution of prostate cancer events, cumulative incidence (per 100), prostate cancer deaths and cumulative mortality (per 100) of prostate cancer, $N = 1{,}196{,}563$

	Events and incidence					Number of deaths and mortality				
	No	%		95%	CI	No	%		95%	CI
Total population (%)	98,392		8.22	8.17	8.27	21,552		1.80	1.78	1.83
Neighborhood linking social capital										
Low	20,384	20.7	7.39	7.29	7.50	5190	24.1	1.88	1.83	1.93
Intermediate	57,730	58.7	8.22	8.15	8.28	12,779	59.3	1.82	1.79	1.85
High	20,278	20.6	9.29	9.17	9.42	3583	16.6	1.64	1.59	1.70
Age (years)										
50–59	30,733	31.2	6.31	6.24	6.38	1686	7.8	0.35	0.33	0.36
60–69	35,783	36.4	10.78	10.67	10.89	4516	21.0	1.36	1.32	1.40
70–79	24,300	24.7	9.99	9.86	10.11	9212	42.7	3.79	3.71	3.86
≥ 80	7576	7.7	5.65	5.52	5.77	6138	28.5	4.58	4.46	4.69
Family income										
Low income	21,004	21.3	7.04	6.94	7.13	7935	36.8	2.66	2.60	2.72
Middle–low income	23,955	24.3	8.01	7.91	8.11	6552	30.4	2.19	2.14	2.24
Middle–high income	25,665	26.1	8.56	8.46	8.67	4036	18.7	1.35	1.30	1.39
High income	27,768	28.2	9.28	9.17	9.39	3029	14.1	1.01	0.98	1.05
Marital status										
Married/cohabiting	70,044	71.2	9.04	8.97	9.11	14,225	66.0	1.84	1.81	1.87
Never married, Widowed, or Divorced	28,348	28.8	6.72	6.64	6.80	7327	34.0	1.74	1.70	1.78
Educational attainment										
≤ 9 years	41,916	42.6	8.05	7.97	8.12	11,658	54.1	2.24	2.20	2.28
10–12 years	21,629	22.0	7.87	7.77	7.98	4079	18.9	1.49	1.44	1.53
> 12 years	34,847	35.4	8.69	8.60	8.78	5815	27.0	1.45	1.41	1.49
Immigrant status										
Sweden	92,113	93.6	8.43	8.38	8.48	20,367	94.5	1.86	1.84	1.89
Other countries	6279	6.4	6.04	5.90	6.19	1185	5.5	1.14	1.08	1.21
Region of residence										
Large cities	35,873	36.5	8.46	8.37	8.54	7300	33.9	1.72	1.68	1.76
Southern Sweden	42,361	43.1	8.25	8.18	8.33	9413	43.7	1.83	1.80	1.87
Northern Sweden	20,158	20.5	7.78	7.67	7.89	4839	22.5	1.87	1.81	1.92
Mobility										
< 5 years	82,210	83.6	8.83	8.77	8.89	13,647	63.3	1.47	1.44	1.49
≥ 5 years	16,182	16.4	6.09	6.00	6.18	7905	36.7	2.98	2.91	3.04
Hospitalization of chronic lower respiratory disease										
No	91,431	92.9	8.23	8.17	8.28	20,360	94.5	1.83	1.81	1.86
Yes	6961	7.1	8.16	7.97	8.35	1192	5.5	1.40	1.32	1.48
Hospitalization of alcoholism and related liver disease										
No	96,202	97.8	8.30	8.24	8.35	21,278	98.7	1.84	1.81	1.86
Yes	2190	2.2	5.90	5.66	6.15	274	1.3	0.74	0.65	0.83
Hospitalization of tobacco smoking										
No	97,480	99.1	8.23	8.18	8.29	21,453	99.5	1.81	1.79	1.84
Yes	912	0.9	7.14	6.68	7.61	99	0.5	0.78	0.62	0.93
Hospitalization of diabetes										
No	87,097	88.5	8.35	8.30	8.41	19,262	89.4	1.85	1.82	1.87
Yes	11,295	11.5	7.35	7.21	7.48	2290	10.6	1.49	1.43	1.55
Hospitalization of obesity										
No	97,663	99.3	8.24	8.19	8.29	21,490	99.7	1.81	1.79	1.84
Yes	729	0.7	6.45	5.98	6.92	62	0.3	0.55	0.41	0.69
Hospitalization of coronary heart disease										
No	77,589	78.9	8.22	8.16	8.28	17,485	81.1	1.85	1.82	1.88

Table 1 (continued)

	Events and incidence					Number of deaths and mortality				
	No	%		95%	CI	No	%		95%	CI
Yes	20,803	21.1	8.24	8.13	8.35	4067	18.9	1.61	1.56	1.66
Hospitalization of hypertension										
No	66,541	67.6	7.63	7.57	7.69	16,960	78.7	1.95	1.92	1.97
Yes	31,851	32.4	9.81	9.70	9.91	4592	21.3	1.41	1.37	1.45

The association between neighborhood linking social capital and prostate cancer incidence is presented in Table 2. A significant association was observed between neighborhood linking social capital and prostate cancer incidence, as individuals living in neighborhoods with low linking social capital were less likely to be diagnosed with prostate cancer than those living in neighborhoods with high linking social capital, after adjusting for potential confounders (Model 4: OR 0.90; 95% CI 0.88–0.93). Similarly, individuals living in neighborhoods with intermediate linking social capital were also less likely to be diagnosed with prostate cancer (Model 4: OR 0.94; 95% CI 0.92–0.96).

We also performed additional analyses to examine the association between neighborhood linking social capital and screening for malignant prostate neoplasms (Table 3). After adjusting for potential confounders, individuals living in neighborhoods with low linking social capital were less likely to be screened compared with those living in neighborhoods with high linking social capital (Model 4: OR 0.71; 95% CI 0.59–0.86). Similarly, a significant association was observed between intermediate neighborhood linking social capital and screening for malignant prostate neoplasms (Model 4: OR 0.82; 95% CI 0.70–0.96).

The association between neighborhood linking social capital and mortality in patients with prostate cancer is presented in Table 4. After adjusting for potential confounding factors, patients with prostate cancer living in neighborhoods with low (Model 4: OR 1.15; 95% CI 1.08–1.23) and intermediate (Model 4: OR 1.09; 95% CI 1.03–1.14) linking social capital were more likely to die from prostate cancer compared with those living in neighborhoods with high linking social capital.

Discussion

We found that low and intermediate levels of neighborhood linking social capital were associated with lower odds of prostate cancer incidence than the reference category (high linking social capital). However, the lower categories of neighborhood linking social capital were associated with higher mortality in patients with prostate cancer. These inconsistent findings could be explained by differences in health checkup attendance. Our study suggests that those who lived in neighborhoods with lower social capital could have been less likely to undergo cancer screening for malignant prostate neoplasms. Thus, the incidence of prostate cancer in neighborhoods with lower social capital might have been an underestimation of the "true" incidence. Therefore, more efforts may be needed to increase prostate cancer screening in men living in neighborhoods with lower linking social capital.

Although the causal mechanisms cannot be understood, several possible explanations behind our findings could be suggested. One possible explanation is that individuals living in higher social capital neighborhoods could encourage others to take part in health checkups more easily due to close social networks within such neighborhoods [8]. For example, a previous study conducted in the United States found that higher social capital was associated with greater adherence to clinical breast examination and mammography screening [22]. In addition, a study conducted in Denmark found that a higher level of neighborhood social capital was associated with a higher probability of participating in the health checkup phase of a population-based lifestyle intervention [23].

Another possible explanation is that individuals living in higher social capital neighborhoods are more likely to maintain social order when they witness deviant behavior [8]. This hypothesis is based on a theory on the occurrence of vandalism [24] but is equally applicable and relevant to the prevention of underage smoking and alcoholism [8]. Studies examining the association between lifestyle-related factors, such as smoking and alcoholism, and prostate cancer have so far found inconsistent results [2]; therefore, further analyses which include interaction terms between social capital and lifestyle-related factors may be worthwhile.

Our results also showed that lower socioeconomic status (SES), i.e., income and educational attainment, were associated with a lower incidence of prostate cancer. A diagnosis of prostate cancer is highly influenced by the availability of prostate cancer screening via, e.g., Prostate-Specific Antigen testing [25]. Considering these results, both lower neighborhood linking social capital and individual SES have independent effects on prostate cancer risk; hence, better social networks among medically underserved populations may be helpful in preventing prostate cancer in Sweden.

Table 2 Odds ratios and 95% confidence intervals for cumulative incidence (per 100) of prostate cancer

	Model 1			Model 2			Model 3			Model 4			
	OR	95%	CI	OR	95%	CI	OR	95% CI		OR	95%	CI	*P* value
Neighborhood linking social capital (ref. High)													
Low	0.78	0.77	0.80	0.77	0.75	0.79	0.90	0.88	0.92	0.90	0.88	0.93	< 0.001
Intermediate	0.88	0.86	0.89	0.87	0.85	0.88	0.96	0.95	0.98	0.94	0.92	0.96	< 0.001
Age				1.01	1.01	1.01	1.02	1.02	1.02	1.02	1.02	1.02	< 0.001
Family income (ref. High income)													
Low income							0.66	0.64	0.67	0.67	0.65	0.68	< 0.001
Middle-low income							0.80	0.78	0.81	0.81	0.79	0.82	< 0.001
Middle-high income							0.89	0.87	0.90	0.89	0.87	0.90	< 0.001
Marital status (ref. married/co-habiting)													
Never married, widowed, or divorced							0.75	0.74	0.76	0.76	0.75	0.77	< 0.001
Immigrant status (ref. born in Sweden)							0.77	0.75	0.79	0.77	0.75	0.79	< 0.001
Education attainment (ref. > 12 years)													
≤ 9 years							0.98	0.96	1.00	0.98	0.97	1.00	0.016
10–12 years							0.98	0.96	0.99	0.98	0.96	0.99	0.007
Region of residence (ref. Large cities)													
Southern Sweden							0.96	0.94	0.98	0.96	0.95	0.98	< 0.001
Northern Sweden							0.92	0.90	0.94	0.92	0.90	0.94	< 0.001
Mobility (ref. < 5 years)							0.65	0.64	0.67	0.67	0.66	0.68	< 0.001
Hospitalization for coronary heart disease										0.92	0.91	0.94	< 0.001
Hospitalization for hypertension										1.28	1.27	1.30	< 0.001
Hospitalization for alcoholism and related liver disease										0.84	0.80	0.88	< 0.001
Hospitalization for chronic lower respiratory disease										1.01	0.98	1.03	0.617
Hospitalization for diabetes										0.85	0.84	0.87	< 0.001
Hospitalization for obesity										0.80	0.74	0.87	< 0.001
Hospitalization for tobacco smoking										0.94	0.88	1.01	0.089
Variance (S.E.)	0.023 (0.002)			0.023 (0.002)			0.016 (0.001)			0.016 (0.001)			
Explained variance (%)	23			23			47			47			
Intraclass correlation	0.007			0.007			0.005			0.005			

Model 1: crude model. Model 2: adjusted for age. Model 3: adjusted for age, family income, marital status, country of birth, education, region of residence, and mobility. Model 4: adjusted for age, family income, marital status, country of birth, education, region of residence, mobility, and comorbidities

OR Odds ratio, *CI* confidence interval, *ref* reference

Table 3 Odds ratios and 95% confidence intervals for encounter for malignant prostate neoplasm screening

	Model 1			Model 2			Model 3			Model 4			
	OR	95%	CI	OR	95%	CI	OR	95%	CI	OR	95%	CI	*P* value
Neighborhood linking social capital (ref. High)													
Low	0.79	0.66	0.95	0.79	0.66	0.95	0.71	0.59	0.86	0.71	0.59	0.86	< 0.001
Intermediate	0.87	0.75	1.02	0.87	0.75	1.01	0.82	0.70	0.96	0.82	0.70	0.96	0.014
Age				1.00	1.00	1.01	1.01	1.01	1.02	1.01	1.01	1.02	< 0.001
Family income (ref. High income)													
Low income							0.54	0.47	0.62	0.55	0.48	0.63	< 0.001
Middle-low income							0.68	0.60	0.76	0.68	0.61	0.77	< 0.001
Middle-high income							0.78	0.70	0.87	0.79	0.70	0.88	< 0.001
Marital status (ref. married/co-habiting)													
Never married, widowed, or divorced							0.63	0.57	0.69	0.64	0.58	0.70	< 0.001
Immigrant status (ref. born in Sweden)							0.93	0.79	1.09	0.93	0.79	1.09	0.374
Education attainment (ref. > 12 years)													
≤ 9 years							0.91	0.83	1.01	0.91	0.82	1.01	0.064
10–12 years							0.96	0.85	1.07	0.95	0.85	1.06	0.379
Region of residence (ref. Large cities)													
Southern Sweden							0.28	0.24	0.33	0.28	0.24	0.33	< 0.001
Northern Sweden							1.80	1.57	2.06	1.81	1.58	2.07	< 0.001
Mobility (ref. < 5 years)							0.73	0.65	0.82	0.76	0.68	0.85	< 0.001
Hospitalization for coronary heart disease										1.00	0.90	1.11	0.968
Hospitalization for hypertension										1.32	1.20	1.44	< 0.001
Hospitalization for alcoholism and related liver disease										0.84	0.62	1.12	0.230
Hospitalization for chronic lower respiratory disease										1.09	0.93	1.28	0.267
Hospitalization for diabetes										0.79	0.69	0.90	< 0.001
Hospitalization for obesity										1.33	0.90	1.95	0.159
Hospitalization for tobacco smoking										1.02	0.65	1.61	0.936
Variance (S.E.)	1.513 (0.089)			1.513 (0.089)			1.327 (0.082)			1.324 (0.082)			
Explained variance (%)	0			0			13			13			
Intra class correlation	0.315			0.315			0.287			0.287			

Model 1: crude model. Model 2: adjusted for age. Model 3: adjusted for age, family income, marital status, country of birth, education, region of residence, and mobility. Model 4: adjusted for age, family income, marital status, country of birth, education, region of residence, mobility, and comorbidities

OR Odds ratio, *CI* confidence interval, *ref* reference

Table 4 Odds ratios and 95% confidence intervals for cumulative mortality (per 100) of patients with prostate cancer

	Model 1			Model 2			Model 3			Model 4			
	OR	95%	CI	OR	95% CI		OR	95%	CI	OR	95%	CI	*P* value
Neighborhood linking social capital (ref. High)													
Low	1.44	1.36	1.54	1.25	1.17	1.33	1.13	1.07	1.21	1.15	1.08	1.23	< 0.001
Intermediate	1.27	1.21	1.34	1.16	1.10	1.22	1.08	1.03	1.14	1.09	1.03	1.14	0.003
Age				1.09	1.09	1.10	1.08	1.08	1.08	1.08	1.08	1.09	< 0.001
Family income (ref. High income)													
Low income							1.38	1.29	1.47	1.39	1.30	1.48	< 0.001
Middle-low income							1.33	1.25	1.41	1.35	1.27	1.44	< 0.001
Middle-high income							1.17	1.10	1.24	1.18	1.11	1.25	< 0.001
Marital status (ref. married/co-habiting)													
Never married, widowed, or divorced							1.14	1.10	1.19	1.13	1.09	1.18	< 0.001
Immigrant status (ref. born in Sweden)							1.01	0.93	1.09	1.03	0.95	1.12	0.424
Education attainment (ref. > 12 years)													
≤ 9 years							1.14	1.09	1.20	1.17	1.12	1.23	< 0.001
10–12 years							1.07	1.01	1.13	1.10	1.04	1.16	0.001
Region of residence (ref. Large cities)													
Southern Sweden							1.13	1.08	1.18	1.12	1.07	1.17	< 0.001
Northern Sweden							1.22	1.15	1.28	1.21	1.14	1.28	< 0.001
Mobility (ref. < 5 years)							1.74	1.67	1.82	1.67	1.60	1.75	< 0.001
Hospitalization for coronary heart disease										0.67	0.64	0.71	< 0.001
Hospitalization for hypertension										0.69	0.66	0.72	< 0.001
Hospitalization for alcoholism and related liver disease										1.00	0.87	1.16	0.968
Hospitalization for chronic lower respiratory disease										0.67	0.62	0.72	< 0.001
Hospitalization for diabetes										0.98	0.92	1.04	0.424
Hospitalization for obesity										0.84	0.62	1.14	0.271
Hospitalization for tobacco smoking										0.93	0.74	1.18	0.549
Variance (S.E.)	0.066 (0.009)			0.034 (0.009)			0.027 (0.009)			0.028 (0.009)			
Explained variance (%)	19			58			67			65			
Intra class correlation	0.020			0.010			0.008			0.008			

Model 1: crude model. Model 2: adjusted for age. Model 3: adjusted for age, family income, marital status, country of birth, education, region of residence, and mobility. Model 4: adjusted for age, family income, marital status, country of birth, education, region of residence, mobility, and comorbidities

OR Odds ratio, *CI* confidence interval, *ref* reference

Our study findings have important implications for further research on social capital and prostate cancer; nonetheless, it had some limitations. First, our results could be influenced by other unmeasured risk factors, such as body mass index (BMI). However, we attempted to adjust for BMI by analyzing hospitalization for obesity. Second, the modifiable area unit problem has been suggested as a potential limitation when using aggregated data [26]. However, the SAMS neighborhoods in our study included similar types of buildings, which imply that SAMS neighborhoods are comparatively homogeneous in Sweden. Third, this study did not consider changes of residence during the follow-up. However, we included mobility before baseline to reduce possible selection bias.

Our study also has many strengths. This large cohort included 1,196,563 men aged over 50 years in Sweden, which increased the generalizability of our results. Moreover, we could eliminate spurious associations due to same-source bias because our neighborhood- and individual-level variables were obtained from different sources. Finally, the prospective design of this study may, in part, reflect some causality.

Conclusions

Our findings show a lower incidence of and higher mortality from prostate cancer in neighborhoods with lower levels of linking social capital in addition to a lower screening. These findings suggest that improved screening efforts, as well as better social networks, may be needed in neighborhoods with lower levels of linking social capital to decrease health disparities in prostate cancer among men.

Author contributions TH, XL, JS, KS worked on the conception of the study; XL performed the statistical analyses; TH, XL, JS, KS contributed to data interpretation; TH drafted the paper. All authors have read and approved the final manuscript.

Funding This research was supported by KAKENHI (Grant Number: 18K11143 to Tsuyoshi Hamano). This work was also supported by the Swedish Research Council to Kristina Sundquist. The funders had no role in the analysis, interpretation of data, or preparation of the manuscript.

Data availability The data used in the present study cannot be shared as it is based on data obtained from Swedish population-based registers with national coverage.

Declarations

Conflict of interest The authors have no confict of interest to disclose.

Ethical approval This study was approved by the Regional Ethical Review Board in Lund.

Statement of human and animal rights The study have been approved by the appropriate institutional research ethics committee and have been performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

Informed consent Participant consent was not obtained as the study was based on registry information.

References

1. Bray F, Ferlay J, Soerjomataram I, Siegel RL, Torre LA, Jemal A (2018) Global cancer statistics 2018: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. CA Cancer J Clin 68:394–424
2. Rawla P (2019) Epidemiology of prostate cancer. World J Oncol 10:63–89
3. Cao Y, Ma J (2011) Body mass index, prostate cancer-specific mortality, and biochemical recurrence: a systematic review and meta-analysis. Cancer Prev Res (Phila) 4:486–501
4. Aune D, Navarro Rosenblatt DA, Chan DS, Vieira AR, Vieira R, Greenwood DC, Vatten LJ, Norat T (2015) Dairy products, calcium, and prostate cancer risk: a systematic review and meta-analysis of cohort studies. Am J Clin Nutr 101:87–117
5. Friedenreich CM, Neilson HK, Lynch BM (2010) State of the epidemiological evidence on physical activity and cancer prevention. Eur J Cancer 46:2593–2604
6. DeRouen MC, Schupp CW, Yang J, Koo J, Hertz A, Shariff-Marco S, Cockburn M, Nelson DO, Ingles SA, Cheng I, John EM, Gomez SL (2018) Impact of individual and neighborhood factors on socioeconomic disparities in localized and advanced prostate cancer risk. Cancer Causes Control 29:951–966
7. DeRouen MC, Schupp CW, Koo J, Yang J, Hertz A, Shariff-Marco S, Cockburn M, Nelson DO, Ingles SA, John EM, Gomez SL (2018) Impact of individual and neighborhood factors on disparities in prostate cancer survival. Cancer Epidemiol 53:1–11
8. Kawachi I, Berkman LF (2014) Social capital, social cohesion, and health. In: Berkman LF, Kawachi I, Glymour MM (eds) Social epidemiology, 2nd edn. Oxford University Press, New York, pp 290–319
9. Putnam R (1993) Making democracy work. Princeton University Press, Princeton
10. Szreter S, Woolcock M (2004) Health by association? social capital, social theory, and the political economy of public health. Int J Epidemiol 33:650–667
11. Hamano T, Li X, Sundquist J, Sundquist K (2019) Neighborhood linking social capital as a predictor of lung cancer: a Swedish national cohort study. Cancer Epidemiol 61:23–29
12. Sundquist K, Hamano T, Li X, Kawakami N, Shiwaku K, Sundquist J (2014) Linking social capital and mortality in the elderly: a Swedish national cohort study. Exp Gerontol 55:29–36
13. Murayama H, Fujiwara Y, Kawachi I (2012) Social capital and health: a review of prospective multilevel studies. J Epidemiol 22:179–187
14. Carrillo-Álvarez E, Kawachi I, Riera-Romaní J (2019) Neighbourhood social capital and obesity: a systematic review of the literature. Obes Rev 20:119–141
15. Kawachi I (2006) Commentary: social capital and health: making the connections one step at a time. Int J Epidemiol 35:989–993
16. Ehsana A, Klaas HS, Bastianen A, Spini D (2019) Social capital and health: a systematic review of systematic reviews. SSM Popul Health 8:100425
17. Sundquist J, Johansson SE, Yang M, Sundquist K (2006) Low linking social capital as a predictor of coronary heart disease in Sweden: a cohort study of 2.8 million people. Soc Sci Med 62:954–963

18. Sundquist J, Hamano T, Li X, Kawakami N, Shiwaku K, Sundquist K (2014) Neighborhood linking social capital as a predictor of psychiatric medication prescription in the elderly: a Swedish national cohort study. J Psychiatr Res 55:44–51
19. Sundquist K, Yang M (2007) Linking social capital and self-rated health: a multilevel analysis of 11,175 men and women in Sweden. Health Place 13:324–334
20. Callas PW, Pastides H, Hosmer DW (1998) Empirical comparisons of proportional hazards, poisson, and logistic regression modeling of occupational cohort data. Am J Ind Med 33:33–47
21. Snijders T, Bosker R (1999) Multilevel analysis: an introduction to basic and advanced multilevel modeling. SAGE Publications Inc., Thousand Oaks
22. Shelton RC, Gage-Bouchard EA, Jandorf L, Sriphanlop P, Thelemaque LD, Erwin DO (2016) Examining Social capital and its relation to breast and cervical cancer screening among underserved Latinas in the U.S. J Health Care Poor Underserved 27:1794–1811
23. Bender AM, Kawachi I, Jørgensen T, Pisinger C (2015) Neighborhood social capital is associated with participation in health checks of a general population: a multilevel analysis of a population-based lifestyle intervention- the Inter99 study. BMC Public Health 15:694
24. Sampson RJ, Raudenbush SW, Earls F (1997) Neighborhoods and violent crime: a multilevel study of collective efficacy. Science 64:918–924
25. Mihor A, Tomsic S, Zagar T, Lokar K, Zadnik V (2020) Socioeconomic inequalities in cancer incidence in Europe: a comprehensive review of population-based epidemiological studies. Radiol Oncol 54:1–13
26. Openshaw S (1983) The modifiable areal unit problem. Geo Books, Norwick