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Prostate Cancer Imaging Trends After a Nationwide Effort to Discourage Inappropriate Prostate Cancer Imaging

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Background   Reducing inappropriate use of imaging to stage incident prostate cancer is a challenging problem highlighted recently as a Physician Quality Reporting System quality measure and by the American Society of Clinical Oncology and the American Urological Association in the Choosing Wisely campaign. Since 2000, the National Prostate Cancer Register (NPCR) of Sweden has led an effort to decrease national rates of inappropriate prostate cancer imaging by disseminating utilization data along with the latest imaging guidelines to urologists in Sweden. We sought to determine the temporal and regional effects of this effort on prostate cancer imaging rates.

Methods   We performed a retrospective cohort study among men diagnosed with prostate cancer from the NPCR from 1998 to 2009 (n = 99 879). We analyzed imaging use over time stratified by clinical risk category (low, intermediate, high) and geographic region. Generalized linear models with a logit link were used to test for time trend.

Results   Thirty-six percent of men underwent imaging within 6 months of prostate cancer diagnosis. Overall, imaging use decreased over time, particularly in the low-risk category, among whom the imaging rate decreased from 45% to 3% ($P < .001$), but also in the high-risk category, among whom the rate decreased from 63% to 47% ($P < .001$). Despite substantial regional variation, all regions experienced clinically and statistically ($P < .001$) significant decreases in prostate cancer imaging.

Conclusions   A Swedish effort to provide data on prostate cancer imaging use and imaging guidelines to clinicians was associated with a reduction in inappropriate imaging over a 10-year period, as well as slightly decreased appropriate imaging in high-risk patients. These results may inform current efforts to promote guideline-concordant imaging in the United States and internationally.

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Widespread use of prostate-specific antigen (PSA) screening has caused a stage migration in prostate cancer, rendering the imaging evaluation of low-risk disease, defined as clinical stage T1 to T2, Gleason score 6 or less, and PSA less than 10 ng/mL, largely unnecessary [1,2]. Through the development of quality measures and clinical guidelines, policy organizations such as the Physicians Quality Reporting System and professional societies have tried to limit the use of whole body radionuclide bone scan and axial imaging of the abdomen and pelvis among patients with low-risk prostate cancer because the rare detection of metastases is outweighed by the harms of false-positive results [3–9]. The success of these efforts on nationwide imaging rates has been mixed, as there continue to be overuse of "inappropriate" imaging among low-risk prostate cancer patients and, paradoxically, simultaneous underuse of appropriate imaging among high-risk prostate cancer patients [10–16]. Recently, the American Society of Clinical Oncology and the American Urological Association again highlighted the need to reduce inappropriate imaging for low-risk prostate cancer

in the Choosing Wisely campaign, a multidisciplinary effort to reduce unnecessary medical testing, decrease overuse of healthcare resources, and improve quality of care [5,17–19]. Given the Choosing Wisely campaign's particular emphasis on the reduction of unnecessary diagnostic imaging [20] and the freedom it affords participants to affect its goals, the description and evaluation of policies to reduce inappropriate prostate cancer imaging are especially important.

Since 2000, the National Prostate Cancer Register (NPCR) of Sweden has engaged in an effort to reduce inappropriate diagnostic imaging among men with low-risk prostate cancer [21]. The NPCR collects data on diagnostic and therapeutic procedures performed within 6 months of prostate cancer diagnosis in over 97% of incident cases in Sweden [22,23]. These data were used to generate local, hospital-level reports of the frequency of imaging use for patients with low-risk prostate cancer. Along with the most recent versions of imaging guidelines from professional societies in Europe, the United States, and Sweden, as well as

important contemporary literature in the field, these utilization data were presented annually to Swedish urologists attending regional and national urology meetings along with the message that reducing inappropriate imaging was important (8,21,23,24). The results of this effort have not been previously reported but are extremely important to determine whether such a strategy effectively reduces inappropriate imaging. These results may also demonstrate unintended consequences, as studies have suggested that policy efforts to reduce inappropriate imaging may also reduce appropriate imaging (10,25).

The aim of this study was to assess the NPCR effort to reduce inappropriate prostate cancer imaging in Sweden by examining imaging trends across the country. We hypothesized that although rates of inappropriate imaging would decrease, rates of appropriate imaging would also decrease. If this hypothesis were true, it would be an important lesson that policy efforts to curb inappropriate prostate cancer imaging, such as Choosing Wisely, might need to be augmented, perhaps with further efforts to encourage appropriate use. If rates of inappropriate imaging did not change or increased during the study period, then the Swedish intervention would be unlikely to be successful in other settings. However, if inappropriate imaging declined during the study period while appropriate imaging improved or remained unchanged, the Swedish intervention might be used as a model to encourage stewardship of health-care resources in other health-care systems and countries.

Methods

Study Design and Patients
We performed a retrospective cohort study to analyze temporal and geographic patterns of prostate cancer imaging in Sweden. The study population consisted of men from the NPCR, which is a national prostate cancer quality registry. Information is provided to patients about the NPCR in all urology clinic waiting rooms as well as online; no written consent is collected, but patients may opt out of the registry at any time. Data from the NPCR, when cross-referenced with the Cancer Register of Sweden (to which reporting is legally mandated), includes information on more than 97% of incident prostate cancer cases (22,26). All patients included in the sample have data on age, date of diagnosis, and name and location of the diagnosing hospital (22). We identified 100 832 men in NPCR diagnosed from 1998 to 2009. We excluded 953 patients with incomplete imaging data, leaving a final cohort of 99 879 men. This study was approved by the Research Ethics Board of Umeå University Hospital.

Definition of Variables
Our primary dependent variable of interest was receipt of imaging such as radionuclide bone scan, computed tomography (CT), or magnetic resonance imaging (MRI) to assess for skeletal metastases. The NPCR records whether this imaging was performed within 6 months of the date of cancer diagnosis. Because NPCR does not specify which imaging modality was used, we examined a randomly selected subgroup of 500 men diagnosed with prostate cancer in 2009 to determine the relative frequencies of each imaging modality.

The independent variables of interest included year of diagnosis and clinical risk category, defined using a modified National

Comprehensive Cancer Network (NCCN) risk stratification (7): 1) low-risk (clinical stage T1–2, Gleason score ≤6, and PSA < 10 ng/mL); 2) intermediate-risk (clinical stage T1–2, Gleason score 7, and/or PSA 10–20 ng/mL); 3) high-risk (clinical stage T3–4 or Gleason score 8–10 or PSA > 20 ng/mL). Categorizing a patient as high-risk required only one high-risk feature, even if other data were missing; for low- and intermediate-risk classification, all three features were required. We selected this classification because of its frequent contemporary use and because its definition of low-risk prostate cancer ensures imaging would have been inappropriate regardless of the imaging guideline employed or the calendar year of diagnosis (8,27). Because of missing data, 627 men who received imaging and, 819 men who did not receive imaging could not be classified into a risk category; they were included in descriptions of "all risk categories" but were excluded from analyses stratified by risk category. Covariates included patient age at diagnosis (years); serum PSA (nanograms per milliliter, collected before treatment and within 6 months of cancer diagnosis), clinical tumor stage (modified International Union Against Cancer staging recommendations), and Gleason score (22).

Statistical Analysis
We analyzed yearly imaging patterns and stratified them by demographic and geographic factors. First, we performed a bivariate analysis to determine the association between receipt of imaging and the described independent variables. We reported P values based on χ^2 tests for categorical variables and Mann–Whitney tests for continuous, nonparametric variables. We determined whether the trend for the differences in yearly imaging rates for each risk category was statistically significantly different from their baseline imaging rate using generalized linear models with a logit link.

We next examined patterns of use between six different regions in Sweden (North, South, Southeast, Stockholm/Gotland, Uppsala/Orebro, and West). We categorized the time periods of diagnosis as 1998 to 1999 (a baseline period before the intervention), 2000 to 2005, and 2006 to 2009. The trend for the difference in imaging rate between time periods was assessed for each region and stratified by risk group using generalized linear models with a logit link, adjusting for patient age and comorbidity.

Statistical analysis was performed using R version 2.15.1 (R Foundation for Statistical Computing, Vienna, Austria). All P values were two-sided with statistical significance at α = .05.

Results

Among 99 879 men diagnosed with prostate cancer between 1998 and 2009, 36 414 (36%) underwent imaging within 6 months of diagnosis (Table 1). Men undergoing imaging were younger (P < .001) than those not undergoing imaging. Seventy percent of men undergoing imaging were high-risk vs only 36% of those not undergoing imaging (P < .001). Men undergoing imaging also had higher-risk features (clinical stage, PSA, and Gleason score) at presentation compared with those not undergoing imaging (all P < .001). Use of prostate cancer imaging demonstrated wide regional variation, with men in the north and southeast regions undergoing imaging 42% of the time, compared with 30% in the western

Table 1. Characteristics of men diagnosed with prostate cancer from the National Prostate Cancer Register of Sweden from 1998 to 2009 (N = 99 879)*

Characteristic	Men receiving imaging (n = 36,414)		Men not receiving imaging (n = 63,465)		P†
	No.	%	No.	%	
Age, y					<.001
<55	1056	2.9	1925	3.0	
55–59	2722	7.5	4897	7.7	
60–64	5531	15.2	9398	14.8	
65–69	7436	20.4	10 950	17.3	
70–74	7543	20.7	10 782	17.0	
75–79	6251	17.2	11 062	17.4	
≥80	5875	16.1	14 451	22.8	
Charlson Comorbidity Index					<.001
0	24 273	66.7	40 755	64.2	
1–2	9768	26.8	18 043	28.4	
≥3	2373	6.5	4667	7.4	
Risk category					<.001
Low	3264	9.0	21 199	33.4	
Intermediate	7112	19.5	16 520	26.0	
High	25 411	69.8	22 927	36.1	
Missing	627	1.7	2819	4.4	
PSA level, ng/mL					<.001
<10	7811	21.5	31 936	50.3	
10–20	8120	22.3	13 127	20.7	
>20	20 056	55.1	16 430	25.9	
Missing	427	1.2	1972	3.1	
Median PSA (IQR)					<.001
	23.2	(11.0–75.0)	9.4	(5.8–21.0)	
Clinical local stage					<.001
T1	8902	24.4	30 901	48.7	
T2	12 213	33.5	19 188	30.2	
T3+	14 465	39.7	12 072	19.0	
Other/missing	834	2.0	1304	2.1	
Gleason score					<.001
2–6	10 567	29.0	34 197	53.9	
7	14 064	38.6	18 783	29.6	
8–10	11 012	30.2	9034	14.2	
Missing	771	2.1	1451	2.3	
Region					<.001
North	4336	11.9	5890	9.3	
South	6906	19.0	12 101	19.1	
Stockholm/Gotland	5961	16.4	11 723	18.5	
Southeast	4862	13.4	6623	10.4	
Uppsala/Örebro	8379	23.0	12 878	20.3	
West	5970	16.4	14 250	22.5	
Year of diagnosis					<.001
1998	3505	9.6	2544	4.0	
1999	3790	10.4	3245	5.1	
2000	3501	9.6	3630	5.7	
2001	3304	9.1	4087	6.4	
2002	3151	8.7	4398	6.9	
2003	3493	9.6	5222	8.2	
2004	3337	9.2	6296	9.9	
2005	3009	8.3	6580	10.4	
2006	2657	7.3	6322	10.0	
2007	2231	6.1	6571	10.4	
2008	2008	5.5	6770	10.7	
2009	2428	6.7	7800	12.3	

* IQR = interquartile range; PSA = prostate-specific antigen.

† All P values are from the χ² test, except for median PSA, which is from the Mann–Whitney test. All tests were two-sided.

region (P < .001). Overall use of prostate cancer imaging trended down from a high of 58% among men diagnosed in 1998 to a low of 23% among men diagnosed in 2008 (P < .001).

Among a randomly sampled subset of 500 patients with detailed imaging information, bone scan was the most common imaging modality. Overall, 88% of men underwent one or more bone scans; bone scan was the sole imaging modality in 75% of patients and was performed in conjunction with other imaging in 13% (Table 2). An additional 6% and 2% of patients underwent only MRI or CT scan, respectively. Prostate cancer imaging rates decreased during the study period (Figure 1). At each time point, imaging use was greater among men with high-risk prostate cancer than among those with intermediate-risk disease. Similarly, imaging use at each time point was greater among men with intermediate-risk prostate cancer than among those with low-risk disease. The decline over time in prostate cancer imaging use was statistically significant among the overall population and within each clinical risk category individually (P < .001 for all three [high-, intermediate-, and low-risk] categories). Whereas in 1998 45% of men with low-risk prostate cancer underwent imaging, the rate declined to a nadir of 3% in 2008 and 2009 (P < .001). Similarly, 63% of men with high-risk prostate cancer underwent imaging in 1998, which also declined over time (43% in 2008 and 47% in 2009) (P < .001).

There was considerable regional variation in prostate cancer imaging (Figure 2A). Nevertheless, across all six regions, prostate cancer imaging declined over time (all P < .001). In virtually all regional and clinical risk subgroups, there was a statistically significant decline in imaging use over time (P < .001 for all, except high-risk patients in the southeast) (Figure 2, B–D). The decline was most pronounced among low-risk patients, where relative imaging rates decreased almost 10-fold. The same monotonic decrease in all time periods across all regions was observed among intermediate-risk patients, as well as high-risk patients in all regions except the southeast. Adjusting for age and comorbidity did not statistically significantly affect the magnitude or the significance of the association between imaging rates and time.
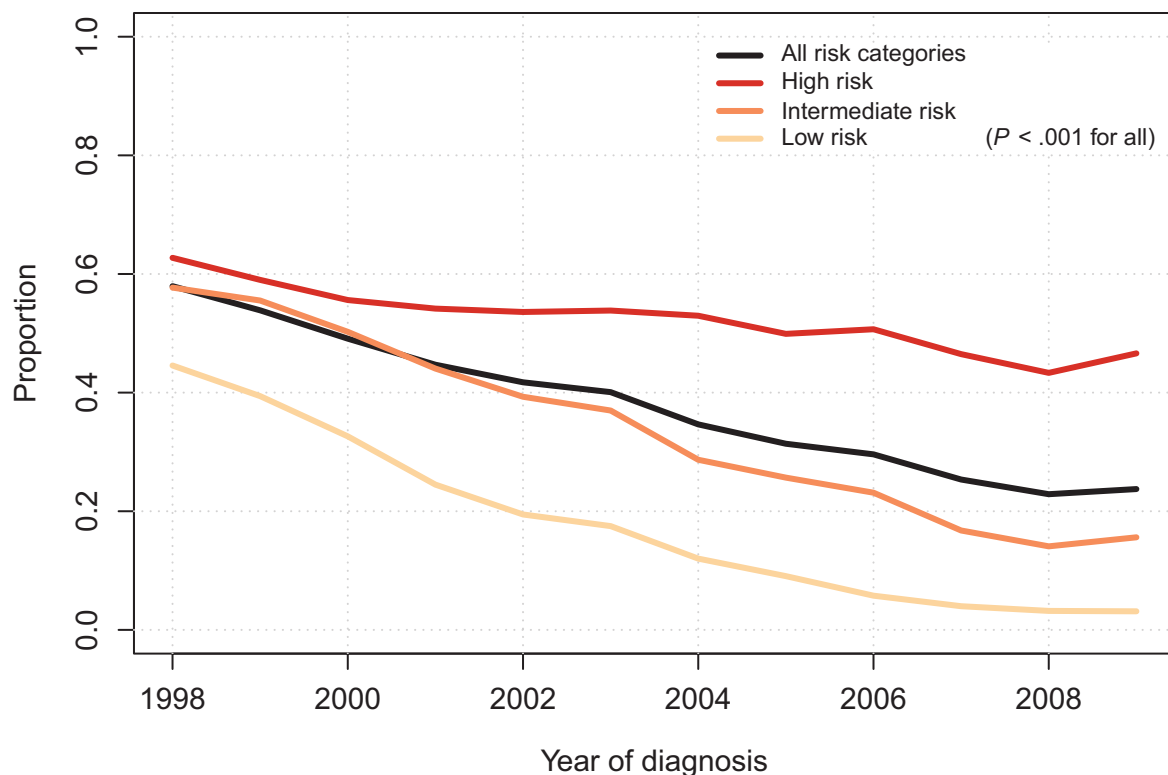
Discussion

This study is the first to report the outcomes of a Swedish effort to reduce national rates of inappropriate prostate cancer imaging. As in the United States, Swedish prostate cancer imaging rates demonstrate wide regional variation. The effort to reduce inappropriate prostate cancer imaging, however, seemed to be effective in nearly all Swedish regions, decreasing imaging among low-risk men from 45% to 3% in a decade. These results compare favorably with previous local efforts to reduce inappropriate imaging (28) and build on those results substantially by demonstrating the ability to improve inappropriate prostate cancer imaging at a national scale. While inappropriate imaging decreased dramatically among low-risk men, this was accompanied by a small, yet statistically significant decrease in appropriate imaging among high-risk men from a peak of 63% to a recent nadir of 47%.

In 1998, the baseline low-risk prostate cancer imaging rate in Sweden was 45%. Per the NCCN guidelines (7), none of these men should have received bone imaging unless they presented with symptoms suggestive of bone pain (8,24). In the United States, the

Table 2. Diagnostic modality used to stage men diagnosed in 2009 with prostate cancer from the National Prostate Cancer Register of Sweden*

Hospital	Bone scan		Bone scan + CT scan		CT scan		Bone scan + plain film		Scint + MRI		CT + plain film		MRI		Plain film		No information available		Total
Malmö	28	80.0%	4	11.4%	1	2.9%	1	2.9%	1	2.9%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	35
Helsingborg	21	91.3%	1	4.3%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	1	4.3%	0	0.0%	0	0.0%	23
Ystad	9	100.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	9
Uppsala	16	72.7%	1	4.5%	0	0.0%	0	0.0%	1	4.5%	0	0.0%	2	9.1%	0	0.0%	2	9.1%	22
Västerås	27	62.8%	7	16.3%	3	7.0%	0	0.0%	4	9.3%	1	2.3%	1	2.3%	0	0.0%	0	0.0%	43
Umeå	21	77.8%	1	3.7%	0	0.0%	0	0.0%	1	3.7%	0	0.0%	0	0.0%	2	7.4%	2	7.4%	27
Skellefteå	5	45.5%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	6	54.5%	0	0.0%	0	0.0%	11
Total	127	74.7%	14	8.2%	4	2.4%	1	0.6%	7	4.1%	1	0.6%	10	5.9%	2	1.2%	4	2.4%	170

* CT = computed tomography; MRI = magnetic resonance imaging.

Figure 1. Time trends in imaging use among men with newly diagnosed prostate cancer by clinical risk categories. Low risk includes patients with tumors designated as clinical stage T1 to T2, Gleason score of 6 or less, and prostate-specific antigen (PSA) of less than 10 ng/mL. Intermediate risk includes patients with tumors designated as clinical stage T1 to T2, Gleason score of 7, and/or PSA of 10 to 20 ng/mL. High risk includes patients with tumors designated as clinical stage T3 and/or Gleason score of 8 to 10 and/or PSA greater than 20 ng/mL. *P* values from generalized linear models with logit link. All statistical tests were two-sided.

Year	All risk categories			Low-risk			Intermediate-risk			High-risk		
	Not imaged	Imaged	Percent of men imaged	Not imaged	Imaged	Percent of men imaged	Not imaged	Imaged	Percent of men imaged	Not imaged	Imaged	Percent of men imaged
1998	2544	3505	57.9	444	357	44.6	450	614	57.7	1456	2450	62.7
1999	3245	3790	53.9	638	415	39.4	596	744	55.5	1771	2549	59.0
2000	3630	3501	49.1	861	417	32.6	705	712	50.2	1845	2311	55.6
2001	4087	3304	44.7	1184	384	24.5	842	663	44.1	1839	2173	54.2
2002	4398	3151	41.7	1387	335	19.5	973	630	39.3	1852	2139	53.6
2003	5222	3493	40.1	1693	359	17.5	1314	771	37.0	1997	2329	53.8
2004	6296	3337	34.6	2395	327	12.0	1634	657	28.7	2035	2291	53.0
2005	6580	3009	31.4	2499	249	9.1	1749	604	25.7	2135	2127	49.9
2006	6322	2657	29.6	2436	149	5.8	1745	525	23.1	1882	1934	50.7
2007	6571	2231	25.3	2454	102	4.0	1898	382	16.8	1957	1700	46.5
2008	6770	2008	22.9	2391	79	3.2	2056	337	14.1	2052	1569	43.3
2009	7800	2428	23.7	2817	91	3.1	2558	473	15.6	2106	1839	46.6
P_{trend}	<.001			<.001			<.001			<.001		

imaging rate among men with low-risk prostate cancer has been reported to be 19% to 74% in a community cohort and 10% to 48% in a Surveillance Epidemiology and End Results (SEER)–Medicare cohort (10–13,16). It is challenging to compare these rates directly across the two countries because the NPCR aggregates all staging imaging into one variable. However, our sampling revealed that 88% of those undergoing imaging had at least a bone scan, whereas

only 11% had any CTs and 10% had any MRI. This suggests that baseline rates of bone scan among low-risk men in Sweden were similar to those among their low-risk counterparts in the United States, whereas rates of axial imaging were likely much lower. During the study period, rates of prostate cancer imaging among low-risk men in Sweden decreased to 3%, substantially lower than those reported in the United States at any time. Because guidelines
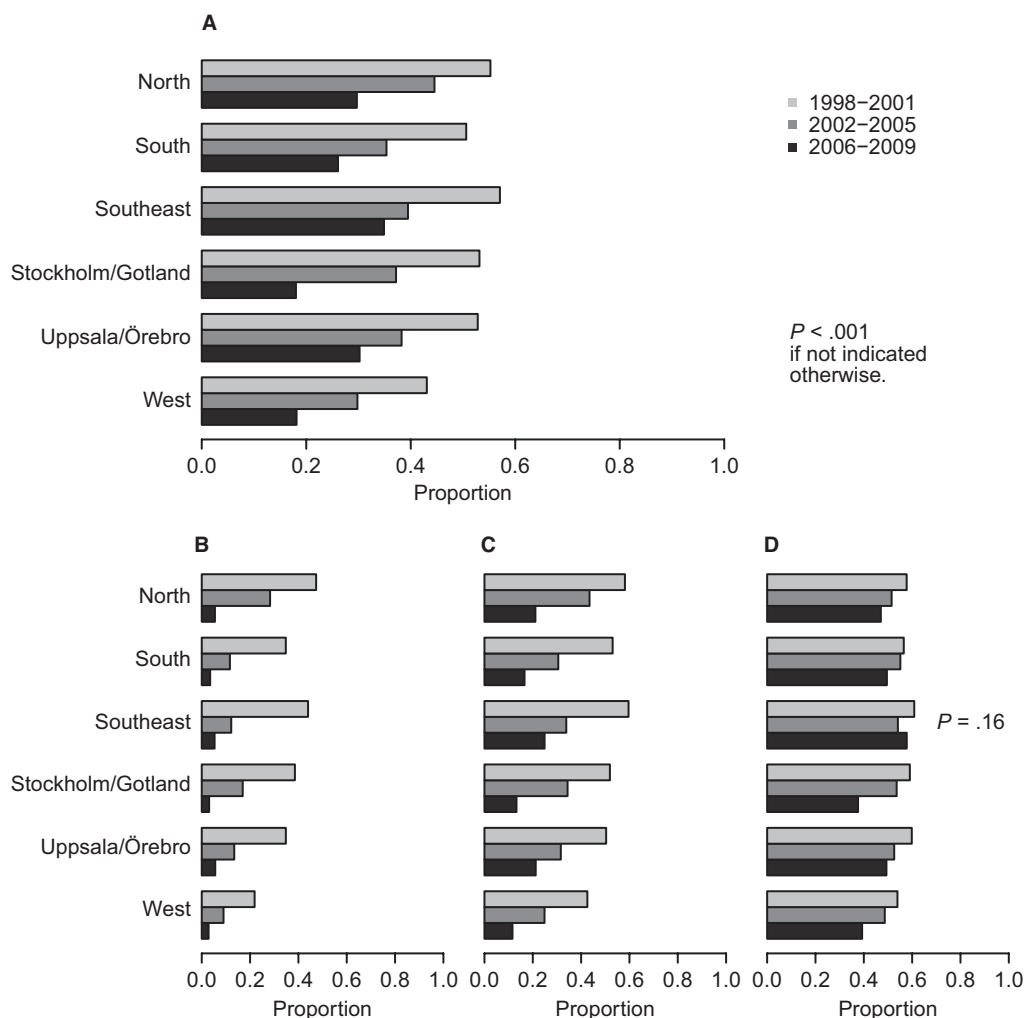
Figure 2. Temporal trends in imaging use for newly diagnosed prostate cancer by region. *P* values from generalized linear models with logit link. All statistical tests were two-sided. **A**) Temporal trends in imaging use for newly diagnosed prostate cancer by region in the overall population. Temporal trends in imaging use are given for newly diagnosed prostate cancer by region within low-risk (**B**), intermediate-risk (**C**), and high-risk (**D**) categories.

suggest imaging for prostate cancer patients with bone pain (7) and 5.6% to 28.7% of men aged 50 to 80 years have back pain (29), the optimal rate of imaging should not be zero, even among men with low-risk features. This 3% rate undoubtedly encompasses some patients presenting with prostate cancer and unrelated back pain, in whom a bone scan is indicated but whose rates of metastatic prostate cancer are vanishingly small (2,30).

Given our retrospective study design, we can only infer an association between the decline in inappropriate prostate cancer imaging in Sweden and the NPCR's efforts to promote guideline-concordant imaging use. Similar to previous work by Miller et al., it is not possible to determine causality with this type of study design (28). The associations described in the analysis could be affected by unmeasured confounding or could result from secular trends unrelated to any specific policy effort, as occurred with imaging rates in the United States (11). Another potential explanation for the decline in inappropriate imaging is the Hawthorne effect, where the behavior of study subjects is modified as the result of the awareness that they are being observed, an explanation supported

perhaps by the decline in imaging rates in 1998 and 1999, a time period before the initiation of the NPCR's effort (31). In spite of these alternate explanations, it remains plausible that interventions such as those in this report and those described by Miller et al. (28) could have had an effect on prostate cancer imaging rates. Miller et al. describe a decline in imaging associated with a small-scale intervention administered in three urology practices located in the United States participating in a quality-improvement consortium. Our study's contribution is to demonstrate that a similar strategy can be applied effectively at a national scale with an associated decline in inappropriate imaging rates, a finding of great interest for policy makers in the United States seeking to improve health-care quality.

In 1998, the baseline high-risk prostate cancer imaging rates in Sweden were 63%, and decreased by 43% in 2008 (rising slightly to 47% in 2009). Based on our risk category definitions and the guidelines advocated in Sweden, all of these men should have undergone an imaging evaluation (8,24). Swedish rates of prostate cancer imaging among men with high-risk disease are considerably

lower than those reported from the SEER–Medicare cohort, where 70% to 75% underwent bone scan and 57% to 58% underwent CT (13,16). These already low rates of imaging among men with high-risk prostate cancer only decreased further during the NPCR's effort to promote guideline-concordant imaging. Clearly in both countries, imaging for high-risk prostate cancer remains underused despite the general overuse of imaging and numerous guidelines encouraging its appropriate use (3–9).

The results of several studies suggest a mechanism for the observed decline in appropriate imaging among men with high-risk prostate cancer during the NPCR's effort to reduce inappropriate prostate cancer imaging. Ko et al. analyzed cardiac catheterization rates among Medicare patients with acute myocardial infarction and found patients living in regions with higher catheterization rates were more likely to undergo catheterization, regardless of whether they needed the procedure (32). Abraham and colleagues found that, after implementation of the initial American Urological Association prostate cancer imaging guidelines, bone scan rates declined substantially among SEER–Medicare patients in whom bone scan was not indicated but also decreased slightly among men in whom bone scan was indicated (10). A follow-up study found a regional-level association between appropriate imaging among high-risk men and inappropriate imaging among low-risk men, a finding termed the thermostat model of health-care resource allocation (25). According to this model, men with high-risk prostate cancer are more likely to undergo appropriate imaging if they reside in a region where inappropriate imaging is more common. A corollary to this model is that policies aimed at lowering rates of inappropriate imaging among men with low-risk prostate cancer may have the unintended consequence of lowering appropriate imaging rates among men with high-risk prostate cancer (25). This is borne out in our analysis, which demonstrates a modest, but statistically significant, decline in imaging among high-risk prostate cancer patients in Sweden during an effective national effort to decrease inappropriate imaging among low-risk patients.

Our analysis has several key strengths, most notably, the high quality of data from the NPCR of Sweden. This population-based registry represents virtually all men diagnosed with prostate cancer across Sweden and eliminates selection bias in the study sample. Similarly, as reporting to the register is mandatory, the health-care resource use records are extremely accurate, eliminating a source of verification bias. Additionally, the registry is well established, allowing us to observe the long-term effects of policy changes.

This analysis also has several limitations. Because this is an initial exploration of imaging use patterns from Sweden, we focused on descriptive statistics rather than complex, multivariable modeling. Although superficially a limitation, it is actually a testament to the clear trends in imaging use that took place during the study period. The body parts imaged by CT and MRI are not recorded, although all studies were obtained to evaluate patients for bone metastasis, making it highly likely that these were images of the spine. The high rate of bone scan use relative to other modalities in 2009 the year from which we reviewed 500 incident prostate cancer cases to determine the types and frequencies of diagnostic tests used, is likely to have been a year in which use of MRI would have peaked

(8,27). This suggests bone scan was at least similarly common throughout the entire study period though it is not possible to confirm whether these patters were constant in other years where such data could not be reviewed. It is challenging to compare directly the various imaging rates across countries and across studies. Some of the reported US imaging rates are based on the same criteria for low-risk disease as this study, whereas other used a broader definition (incorporating patients with more aggressive features). This phenomenon could help explain the higher imaging rates observed in other studies (13). Finally, differences across health-care systems might reduce the generalizability of the NPCR effort to a country not having a similar uniform national health-care system where decisions regarding capacity for diagnostic imaging are made by regional authorities (33,34). Such centralization facilities the dissemination of information, implementation of policy, and accurate record-keeping, which are critical for continuous quality improvement efforts. A final limitation is the lack of consensus over the interpretation of data supporting imaging in high-risk patients (35–38). Some of the underuse of imaging among high-risk patients may be the result of physicians' reluctance to use imaging in an era when metastatic disease is so uncommon.

A national effort to reduce inappropriate prostate cancer imaging by disseminating hospital-level utilization data and contemporary imaging guidelines to urologists in Sweden was associated with a reduction in inappropriate imaging from 45% to 3%. Although appropriate imaging suffered to a small extent, these national-level results are truly remarkable because many previous guidelines and policy efforts have failed to reduce inappropriate prostate cancer imaging in the United States. The Swedish experience could inform future US health policy efforts, such as the Choosing Wisely campaign, in several ways. Policymakers should be encouraged that they have selected a solvable problem. However, to avoid unintended consequences, our analysis suggests that efforts to curb inappropriate prostate cancer imaging might best be coupled with efforts to encourage appropriate use. Without some sort of further modification, policies to reduce inappropriate prostate cancer imaging may improve care for patients with low-risk disease at the expense of those with high-risk features.

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