Current and projected annual direct costs of screening asymptomatic men for prostate cancer using prostate-specific antigen

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Abstract

Background: Concern over the cost of screening for asymptomatic prostate cancer by means of prostate-specific antigen (PSA) testing has played an important role in PSA screening policy. However, little is known about the true costs of current PSA screening in Canada and how costs may change in the future.

Methods: The authors performed a cost identification study from the perspective of provincial ministries of health. They used data from published reports, hospital discharge data, claims data from several provinces, a laboratory survey, a national survey of knowledge, attitudes and beliefs about screening, a provincial cancer registry and expert opinion to estimate current first-year screening costs. Using demographic data from Statistics Canada and various scenarios regarding changes in screening patterns, the authors derived estimates of the future costs of PSA screening.

Results: In 1995 PSA screening cost an estimated $45 million (range $40 million to $84 million). Treatment accounted for over 61% of total costs, whereas screening, diagnosis and staging accounted for 35%. Screening all eligible men in Canada in 1995 would have cost $317 million (range $356 million to $691 million), more than the costs of all prostate cancer care in that year. Annual recurrent screening for all eligible men in 2005 would cost $219 million (range $208 million to $412 million). Projections from existing trends suggest that annual costs of PSA screening in 2000 are likely to increase from the estimated $45 million to approximately $66 million (range $59 million to $126 million).

Interpretation: PSA screening is costly, but even universal screening would consume a smaller share of national health expenditures than previous studies have suggested. Costs attributable to PSA screening may increase in the future owing to changes in utilization patterns and demographic shifts.

Résumé

Contexte : Les préoccupations que soulève le coût du dépistage du cancer de la prostate asymptomatique par dosage de l'antigène prostatique spécifique ont joué un rôle important dans la politique sur le dépistage par dosage de l'antigène. On ne sait toutefois pas grand chose des coûts réels des moyens actuels de dépistage par dosage de l'antigène au Canada, ni de l'évolution future possible des coûts.

Méthodes : Les auteurs ont réalisé une étude de définition des coûts du point de vue des ministères provinciaux de la Santé. Ils ont utilisé des données provenant de rapports publiés, des données sur les congés d'hôpital, des données sur des demandes de paiement provenant de plusieurs provinces, une enquête réalisée auprès de laboratoires, une enquête nationale portant sur les connaissances, les attitudes et les croyances au sujet du dépistage, un registre provincial du cancer et des avis d'experts pour estimer les coûts actuels de dépistage de la première année. Se fondant sur des données démographiques provenant de Statistique Canada et sur divers scénarios concernant les changements des tendances du dépistage, les auteurs ont dérivé des estimations des coûts futurs du dépistage par dosage de l'antigène.

Evidence

Études

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Résultats : En 1995, on estime que le coût du dépistage par dosage de l'antigène a atteint 45 millions de dollars (intervalle de 40 à 84 millions). Le traitement a englouti plus de 61 % des coûts totaux tandis que le dépistage, le diagnostic et la détermination du stade en ont absorbé 35 %. Le dépistage de tous les hommes admissibles au Canada en 1995 aurait coûté 317 millions de dollars (intervalle de 356 à 691 millions), ce qui dépasse le total des coûts de tous les soins dispensés pour le cancer de la prostate au cours de l'année en question. Le dépistage annuel répétitif chez tous les hommes admissibles en 2005 coûterait 219 millions de dollars (intervalle de 208 à 412 millions). Les projections fondées sur les tendances actuelles indiquent que les coûts annuels du dépistage de l'antigène prostatique spécifique en 2000 atteindront probablement près de 66 millions de dollars (intervalle de 59 à 126 millions) plutôt que les 45 millions actuellement prévus.

Interprétation : Le dépistage par dosage de l'antigène prostatique spécifique est coûteux, mais même le dépistage universel engloutirait une partie moindre des dépenses nationales de la santé que des études antérieures l'avaient laissé entendre. Les coûts attribuables au dépistage par dosage de l'antigène peuvent augmenter à l'avenir à cause de changements des tendances de l'utilisation et de l'évolution de la démographie.

The health consequences of the trend toward increasing use of prostate-specific antigen (PSA) testing for early detection of prostate cancer are large but not yet fully understood. Screening may reduce rates of death from cancer and avert morbidity from late-stage disease, but it may also result in unwanted labelling effects and frequent complications of treatment.[1,2]

The economic consequences of screening are also large and not well understood. Screening has resulted in higher utilization rates of PSA testing, prostate biopsy, radical prostatectomy and radiotherapy in both the United States and Canada.[3,4] Descriptive costing studies in the United States have given estimates of the cost of universal screening of eligible men of US$11 billion to US$28 billion.[5–7] To our knowledge, no estimates of the costs of current PSA screening based on actual utilization data have been published. In addition, there are no published Canadian estimates of current or projected screening costs. We performed a study to estimate current and future costs of PSA screening in Canada.

Methods

Study design

Our analysis is a descriptive costing study. We identified actual first-year costs associated with PSA screening in Canada for patients screened in the calendar year 1995, including referral, diagnostic and staging tests, treatment and follow-up. In addition, we projected costs of PSA screening in 2005, based on alternative assumptions about changing patterns of PSA test use and demographic shifts.

Because we considered only first-year costs, we did not incorporate long-term cost savings associated with prevention of late-stage disease and death from prostate cancer into our analysis. Although our cost projections approximate short-term expenditures incurred by payers, they are an overestimate of the long-term, net economic consequences of PSA screening.

Economic assumptions

We estimated aggregate costs by separately estimating resource utilization and unit costs for each cost category. We calculated costs in 1995 Canadian dollars. When 1995 data were not available, we adjusted for inflation using Statistics Canada's consumer price index for health and personal care.[8]

Because we were concerned primarily with determining direct cash outlays by provincial ministries of health, we performed the analysis from a third-party payer perspective. Costs borne by patients were not included. We also did not measure indirect costs or lost productivity associated with illness and premature death.[9–13]

We used a range of data sources and assumptions to estimate quantitatively the degree of uncertainty associated with each component of cost. For each cost category we estimated a baseline cost by multiplying together the lowest unit cost and the use estimate we judged to be most reliable. We also estimated a high cost by multiplying our highest unit cost estimate by our highest utilization estimate, and a low cost by multiplying our lowest unit cost by our lowest utilization estimate.

Sources of utilization data

We estimated the number of PSA tests done for screening from a 1995 cross-sectional national survey of 629 Canadian men that obtained information on the use of PSA tests and on knowledge, attitudes and beliefs regarding screening.[14] We also obtained data on the use of PSA testing directly from the Medical Services Plan of British Columbia and the Health Services Utilization and Research Commission of Saskatchewan as well as from a survey of all laboratories in Ontario.[15]

In addition, we used the databases of the Canadian Institute

for Health Information (CIHI) and Cancer Care Ontario to obtain information about patterns of care. CIHI hospital discharge data contain information about inpatient care in Canadian hospitals, including length of stay, most responsible diagnosis and other diagnoses, and types of procedure performed. The CIHI National Physician Database aggregates insurance claims data provided by provincial health care plans to provide national estimates of the frequency and type of physician services that are reimbursed. The Cancer Care Ontario database links clinical data regarding care of patients with cancer in the province with CIHI hospital discharge data.

We used data from the National Cancer Incidence Reporting System[16] to estimate the number of cancer cases detected through PSA screening. We used published data from a 4-year longitudinal screening study involving over 10 000 community volunteer subjects[17,18] to estimate the positive predictive value of PSA screening and the proportion of men going on to biopsy, staging and treatment after first and recurrent testing.

Population eligible for screening

We obtained age- and sex-specific population projections for Canada and the provinces for 1995 through 2005 from Statistics Canada.[19] In keeping with clinical guidelines,[20] men aged 50 to 74 years were considered potential candidates for PSA screening in future universal screening programs. For the purposes of assessing use in 1995, we considered that screening may have occurred in men as young as 40.

Number of PSA tests performed

We estimated the number of PSA tests performed by multiplying the number of men who had reported undergoing a PSA test for screening purposes[14] by the number of eligible men in Canada. We generated supplemental national estimates of the number of tests done for screening by multiplying the number of tests per eligible man in British Columbia (0.104) (Michael Hsieh, Corporate and International Project Coordinator, Medical Services Plan, British Columbia Ministry of Health, Victoria: personal communication, 1997) and Ontario (0.078[15]) by the number of eligible men in Canada and by assuming that 60% of PSA tests are done for screening.[14] Estimates based on extrapolation from provincial utilization data were similar to survey-derived estimates (Table 1).

Number of referrals, biopsy procedures and cancer cases detected

We used published data to estimate the frequency of abnormal PSA values among screenees, the probability of undergoing biopsy and the probability of cancer after biopsy.[17,21]

Number of cancer cases diagnosed through PSA screening: extrapolation of incidence trends

We verified the accuracy of our predictions of number of prostate cancer cases detected through screening using another method. Using data from the Canadian Cancer Incidence Reporting System[22] and software developed at Health Canada (Orius, version 1.0.2, Disease Surveillance System, Cancer Bureau, Health Canada, Ottawa), we calculated age-standardized incidence rates among men aged 40 years or more for 1970–1989 and for 1990–1993, with the 1991 Canadian population as the standard. Assuming a constant rate of change in the age-standardized incidence rates for each period, we applied a linear model to log-transformed rates and estimated the slope of the regression line. The estimated slope was then transformed back to represent the percentage annual increase. The annual rate of change from 1970 to 1989 (2.96%) was used to project the number of prostate cancer cases that would have been detected in the absence of PSA testing during 1990–1995.

The regression equation was based on incident cases to 1989 because Health Canada records and utilization data for Ontario indicate that the use of PSA testing increased markedly in 1990 following the approval of 8 new PSA tests.[15,23] This date also corresponds to an inflection in the prostate cancer incidence graph (Fig. 1).[3,23]

Using the same method, we projected the expected number of incident cases for 1994 and 1995 based on the annual percentage change in reported prostate cancer incidence over the period 1990–1993 (incidence data were available to 1993 only). We then calculated the number of prostate cancer cases that could be attributed to PSA testing in 1995 by subtracting the expected number of cases in the absence of PSA testing from the number projected to be diagnosed in 1995 (Fig. 1). The estimates of the number of cancer cases diagnosed through PSA screening obtained with the 2 methods were similar (Table 1).

Staging, treatment and follow-up

Because treatment patterns in clinic-based screening programs may be different from those observed at a population level, we supplemented published estimates with actual utilization data. First, we obtained data on the frequency of hospital discharge with an International Classification of Diseases[24] principal diagnosis code of prostate neoplasm (185.0) and a principal procedure code of retropubic (72.3, 72.4) or perineal (72.52) prostatectomy. We also obtained CIHI billing data for provincial fee codes associated with retropubic and perineal prostatectomy. Finally, all newly diagnosed cases of prostate neoplasms in 1995 were identified from the Cancer Care Ontario database. We determined the frequency of all procedures, including radical prostatectomy, radiotherapy, orchiectomy and transurethral resection of prostate, for patients with prostate cancer in the calendar year following diagnosis.

From hospital discharge and billing data, we estimated that 2800 to 3700 radical prostatectomies were performed in patients with prostate cancer in Canada in 1995. As a baseline and lower bound estimate, we assumed that the proportion of patients treated surgically was the same for those with disease detected through screening and those with disease detected in other ways. As an upper bound estimate, we assumed that 75% of all radical prostatectomies were performed in patients with cancer detected through screening.

We estimated the proportions of patients treated with radiotherapy, transurethral resection of the prostate and orchiectomy from the Cancer Care Ontario database. For baseline and lower bound estimates, we assumed that the distribution of treatment methods for cancer cases detected through screening was the same as for cases detected through other means. For our upper bound estimate, we assumed that 75% of the patients with prostate cancer who received radiotherapy had disease detected through screening but that orchiectomy and transurethral resection of the prostate were less common (50% of the baseline rate) because definitive therapy (surgery or radiation) is performed in 74% of all cases identified through screening (source: Cancer Care Ontario database). For baseline and upper bound estimates of the fre-

Table 1: Resource utilization data and assumptions used to estimate costs of screening for prostate cancer by means of prostate-specific antigen (PSA) testing in Canada in 1995

Variable	Estimate		
	Baseline	Low	High
% of men who had PSA test in preceding year[14]			
Atlantic provinces	9.7	–	–
Quebec	7.3		
Ontario	7.3		
Saskatchewan and Manitoba	10.5		
Alberta and Northwest Territories	4.9		
British Columbia and Yukon Territory	3.2		
Canada	7.3		
No. of PSA tests done for screening purposes	533 402[14]	447 659*	601 424†
% of men with PSA level > 4.0 ng/mL[17,18]			
First screening	10	–	–
Subsequent screening	5		
No. of abnormal PSA test results‡	35 604	29 881	40 144
No. of referrals for positive PSA test result‡	35 604	29 881	40 144
% of men with high PSA level undergoing biopsy[17,18]			
First screening	86	–	–
Subsequent screening	64		
% of men found to have prostate cancer at biopsy[17,18]			
First screening	34	–	–
Subsequent screening	31		
No. of cancers detected	9 521‡ 9 074§	7 990‡	10 735‡
% of cancers staged, given positive biopsy result[17,18]	98	–	–
No. of radical prostatectomies	3 407¶	3 200**	3 799††
% of men with screening-detected prostate cancer treated by			
Radical prostatectomy	19‡‡	19‡‡	30§§
Radiotherapy	27‡‡	27‡‡	44§§
Hormone therapy¶ ¶	20	10	20
Orchiectomy	11‡‡	11‡‡	6¶ ¶
Transurethral resection of prostate	24‡‡	24‡‡	12¶ ¶
Complications with radical prostatectomy, % of procedures[2]			
Rectal injury requiring colostomy	0.3	–	–
Dilation of urethral stricture	12.4	–	–
Sphincter repair for urinary incontinence	0.4	–	–
Complications with external beam radiation therapy, % of procedures[2]			
Rectal injury requiring colostomy	2.3	–	–
Dilation of urethral stricture	4.5	–	–
Sphincter repair for urinary incontinence	0	–	–

*Based on extrapolation from Ontario data.[15]
†Based on extrapolation from data reported by the Medical Services Plan of British Columbia.
‡Calculated using data on use of PSA testing and published data describing investigations in patients with elevated PSA levels.[17,18]
§Extrapolation from incidence trends. See the Methods.
¶Canadian Institute for Health Information (CIHI) National Physician Database.
**CIHI hospital discharge data.
††Cancer Care Ontario database.
‡‡Cancer Care Ontario database, assuming that the pattern of care is the same for cancers detected through PSA screening and those detected by other means.
§§Cancer Care Ontario database, assuming that 75% of treatments are for cancers detected through PSA screenings.
¶ ¶Based on expert opinion.

quency of orchiectomy, we assumed that 20% of patients are treated with hormonal therapy and, for the lower bound estimate, that 10% are so treated (assumptions based on expert opinion).

Unit costs

We obtained 1995 costs for the diagnosis and treatment of prostate cancer (Table 2) from the Royal Victoria Hospital, Montreal, and the Régie de l'assurance-maladie du Québec (Quebec Health Insurance Plan).[25] In addition, we obtained a set of Ontario costs. Fully allocated costs for diagnostic tests were abstracted from the case-costing system at The Toronto Hospital (Transition Systems Incorporated). We estimated costs for physician services using the Ontario Health Insurance Plan fee schedule.[31] Costs for external beam radiation therapy were obtained from a detailed 1994 microcosting study at Princess Margaret Hospital, Toronto[29] (Dr. Padraig Warde, Department of Radiation Oncology, Princess Margaret Hospital: unpublished data, 1997). We estimated the costs of radical prostatectomy through the Ontario Case Cost Project, a joint initiative of the Ontario Ministry of Health and the Ontario Hospital Association. We identified 148 cases of radical prostatectomy performed in university-affiliated and non-university-affiliated hospitals throughout Ontario and used the average cost for all identified cases. We estimated the costs of drug therapy from the Ontario Drug Benefit Formulary.[30] Finally, we estimated costs for all treatment, including treatment of complications, by means of the case mix group/resource intensity weight method,[26–28] using the average cost per weighted case for all Ontario hospitals ($1400).

Future costs

We attempted to project future costs associated with PSA screening by modelling several scenarios. First, we estimated costs that would have accrued from nationwide screening programs in 1995 and 2005. For 1995 estimates we used baseline unit costs but assumed that all eligible men (aged 50 to 74 years) would undergo a first PSA test for screening purposes. We also estimated the annual costs of screening, assuming that all eligible men had been screened at least once in the past. Finally, we used Statistics Canada demographic projections[19] to estimate the number of men eligible for screening in 2005 and the costs of recurrent screening in this population.

In addition, we estimated the rate at which cancer detected through screening was rising by subtracting the annual increase in cancer incidence in the era before PSA testing (3.0%) from the rate observed after 1990 (11.2%). We assumed that real (inflation-adjusted) costs of screening and treatment per patient would be constant over 5 years (1995–2000) but that the rate at which cancer was detected and treated would rise by 8.2% per year.

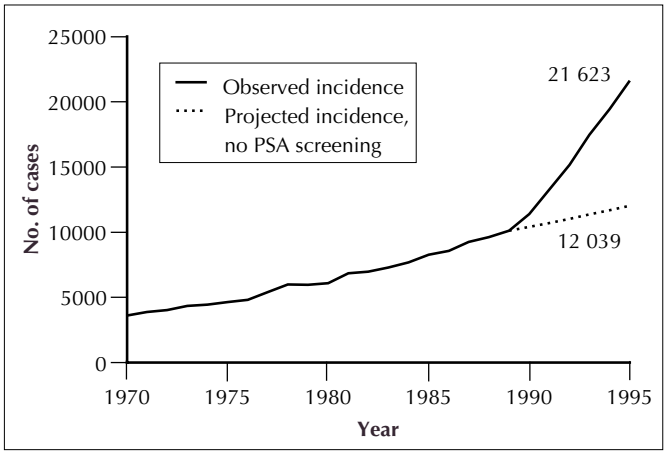

Fig. 1: Estimated excess number of detected cases of prostate cancer attributable to prostate-specific antigen (PSA) screening. Projections beyond 1989 assume an increase of 2.96% per year in expected frequency, and projections beyond 1993 assume an increase of 11.22% per year in observed frequency. The data suggest that 9584 cases were detected through PSA screening in 1995.

Results

Costs of screening, diagnosis and treatment in 1995

We estimated that $45 million (range $40 million to $84 million) was spent in 1995 on diagnostic testing, treatment and follow-up related to PSA screening (Table 3). This represents a first-year direct cost of about $121 per person screened. The cost of the test itself represents 13% of overall costs. The entire diagnostic cascade of screening, biopsy and staging accounts for 35% of overall costs. Treatment of cancer identified through screening accounted for the bulk (over 61%) of direct costs, with the remainder (4%) accounted for by follow-up care.

The distribution of costs across provinces and territories largely followed the population distribution of men eligible for screening. Men in Quebec and Ontario accounted for 27% and 39% respectively of the screening costs as well as 26% and 38% of potential screenees. Provinces to the west of Ontario incurred screening costs below the national average, whereas the Atlantic region incurred higher costs. Regional cost differences were accounted for largely by differences in screening intensity and, to a lesser extent, by differences in the frequency of radical prostatectomy.

The cost of screening and of treating screening-detected prostate cancer within a single year represented approximately one-quarter to one-third of the cost of caring for all surviving patients with prostate cancer, including those in whom the disease was diagnosed in all previous years (Table 4). Relative to total direct health care expenditures, however, the total amount spent on PSA screening was comparatively modest, accounting for less than 1.4% of all cancer costs and about 0.1% of the direct cost of all illness in Canada in 1993 (Table 4).

Future costs

If PSA screening trials currently under way show that screening reduces rates of death from prostate cancer, the use of PSA testing may skyrocket, with dramatically escalated costs.

Table 2: Unit cost estimates, in 1995 dollars

Cost category	Cost, $			
	Baseline	Low	High	Other
PSA test performed during routine visit	11*	11*	26†	12‡
Urologist consultation				
Consultation	36§	36§	52¶	
Hospital costs	40*	40*	37‡	
Total	76	76	89	
Biopsy				
Biopsy professional fee**	65§	65§	128¶	
Pathology professional fee	33§	33§	–	41‡
Laboratory costs	120*	120*	314††	105‡
Total	218	218	442	
Staging				
Bone scintigraphy	79*	79*	128‡	
Chest radiography	30*	30*	36‡	
Complete blood count	5*	5*	7‡	
Biochemistry panel	5*	5*	5‡	
Total	120	120	175	
Radical prostatectomy				
Surgery professional fee	672*	672*	727§§	707¶
Anesthesia professional fee	161§	161§	131¶	
Hospital costs	3683*	3683*	7120‡‡	5438‡, 6051††
Total	4516	4516	7978	
External beam radiation therapy (professional fees and hospital costs)	4257††	4257††	5260*§	4845¶¶
Follow-up (6 mo following diagnosis, for suspected or diagnosed prostate cancer)				
Specialist visit (urologist)	36§	36§	36¶	
Family physician visit	25§	25§	25¶	
PSA test	11*	11*	12‡	
Total	71	71	72	
Hormone therapy (6 mo)***				
Gonadotropin-releasing hormone antagonist (e.g., Zoladex @ 3.6 mg/mo), 6 visits + injections	2400	2400	2400	
Gonadotropin-releasing hormone antagonist + nonsteroidal antiandrogen (e.g., flutamide @ 250 mg 3 times per day)	3575	3575	3575	
Steroidal antiandrogen (e.g., cyproterone acetate @ 200 mg/d)	1741	1741	1741	
Orchiectomy	1690*	1690*	2190††	
Transurethral resection of prostate††	2540	2540	2540	
Rectal injury requiring colostomy	2639*	2639*	9230††	
Dilation of urethral stricture	120*	120*	466††	

*Royal Victoria Hospital, Montreal.[25]
†British Columbia Medical Services Plan.
‡The Toronto Hospital.
§Régie de l'assurance-maladie du Québec (RAMQ).[25]
¶Ontario Health Insurance Plan (OHIP).
**RAMQ fees include fees for transrectal ultrasonography and biopsy of the prostate. OHIP fees include intracavitary ultrasonography, ultrasound guidance of biopsy and needle biopsy of the prostate.
††Costs derived using the case mix group resource intensity weight method.[26–28]
‡‡Ontario Case Cost Project, average cost of all cases (n = 148) of radical prostatectomy with primary diagnosis of prostate neoplasm.
§§Mean reimbursement, CIHI National Physician Database.
¶¶Princess Margaret Hospital, Toronto.[29]
***Ontario Drug Benefit Formulary.[30]

Table 3: Baseline estimate of costs associated with PSA screening in 1995 dollars

Region	Cost, $ million											
	PSA test	Referral	Biopsy	Staging	Radical prostatectomy	Radiotherapy	Hormone therapy	Orchiectomy	Transurethral resection of prostate	Follow-up	Complications	Total
Canada												
Baseline	5.69	2.71	6.13	1.12	7.11	10.80	4.80	1.77	2.65	1.59	0.25	44.63
Low*	4.78	2.27	5.14	0.94	7.11	10.80	2.40	1.77	2.65	1.59	0.25	39.72
High†	13.67	3.58	14.05	1.84	20.28	21.53	4.80	1.14	1.33	1.63	0.83	84.08
Atlantic provinces	0.64	0.30	0.69	0.13	0.80	1.21	0.54	0.20	0.30	0.18	0.03	5.00
Quebec	1.51	0.72	1.62	0.30	1.89	2.86	1.27	0.47	0.70	0.42	0.07	11.83
Ontario	2.22	1.05	2.39	0.44	2.77	4.21	1.87	0.69	1.03	0.62	0.10	17.38
Saskatchewan and Manitoba	0.61	0.29	0.65	0.12	0.76	1.15	0.51	0.19	0.28	0.17	0.03	4.76
Alberta and Northwest Territories	0.35	0.17	0.38	0.07	0.44	0.67	0.30	0.11	0.16	0.10	0.02	2.76
British Columbia and Yukon Territory	0.37	0.18	0.40	0.07	0.46	0.70	0.31	0.12	0.17	0.10	0.02	2.91

*Derived by multiplying the lowest utilization estimate by the lowest unit cost.
†Derived by multiplying the highest utilization estimate by the highest unit cost.

We estimate that screening all eligible men aged 50 to 74 years would incur first-year costs of $356 million to $691 million, an amount that considerably exceeds current expenditures on prostate cancer. This represents about 1% of all direct health care costs and is comparable to annual direct costs of all female (breast and genital) cancers, asthma, perinatal care and treatment, or diabetes mellitus (Table 4). However, if this same cohort is screened recurrently, the annual cost would be much lower after the first year of screening. We estimate 1995 costs for recurrent screening to be approximately $163 million, about 0.4% of all direct health care costs, 4 times higher than current screening expenditures. By 2005, annual universal screening would incur costs of $208 million to $412 million (Table 5).

Net costs per screenee fall dramatically with recurrent screening for 2 reasons. First, cancer detection rates decrease with subsequent screening.[18,36,37] The second factor is compliance. In our model of recurrent screening, rates of compliance with prostate biopsy after a positive PSA test result fall dramatically with second and subsequent tests. Thus, introduction of a universal PSA screening program is likely to lead to a substantial increase in short-term screening expenditures but less significant long-term effects.

Predicting future costs by extrapolating current incidence trends leads to similar conclusions. If the incidence of screening-detected cancer continues to increase at a rate of 8.2% per year, costs by 2000 will be about $66 million (range $59 million to $126 million), about 0.15% of direct health care costs in 1995.

Table 4: Economic burden of selected diseases in Canada (direct costs only)

Disease or intervention	Estimated cost, $ million*	% of total direct costs
Nationwide screening for prostate cancer	208 (55–567)†	0.1–1.3
Prostate cancer‡	193	0.4
Blood diseases§	274	0.6
Birth defects§	305	0.7
Asthma¶	306	0.7
Female cancers	329	0.7
Perinatal care/treatment§	551	1.2
Diabetes mellitus§	577	1.3
Infectious and parasitic diseases§	787	1.8
Stroke§	1 444	3.3
Coronary artery disease§	2 075	4.7
Cancer§	3 221	7.3
All diseases	44 130	100.0

*1993 dollars.
†1995 costs.
‡Estimate based on the assumption that 6% of direct costs for all cancer cases is spent on prostate cancer.[32,33]
§Costs adapted from reference 34.
¶Costs derived from reference 35.

Interpretation

We found that, although PSA screening is not inexpensive, in 1995 it accounted for a small proportion of the direct costs of cancer care and a very small proportion of all direct health care costs. Although future costs may increase as a result of increasing use and demographic shifts, previous predictions that PSA screening will account for 5% of total health care expenditures[5] are probably overstated. The most plausible scenario, that the use of PSA screening will continue to increase at current rates, suggests that costs would rise from $45 million to $66 million by 2000 and account for less than 0.15% of the nation's direct health care costs. However, publication of results of ongoing screening trials could have a dramatic, almost immediate effect on the use of PSA screening, rendering extrapolation from current trends somewhat uncertain.

We have attempted to account for uncertainty by providing ranges of estimates for both utilization and unit cost variables and incorporating these ranges in aggregate cost estimates. The true current costs of PSA screening are most likely lower than our upper bound estimate. Our baseline estimates of PSA test use and cancer detection rate closely match estimates derived from independent data. Some uncertainty remains about treatment patterns in screening-detected cancer cases, but our high and low estimates incorporate a wide range of potential variation in treatment patterns. We derived estimates of screening use after treatment from the literature rather than from actual utilization data, but this variable contributes only a small proportion to overall costs.

Our attempts to predict future costs associated with PSA screening are surrounded by greater uncertainty. A universal screening program will not result in screening of all eligible men. Rates of compliance at all stages of the process (screening, biopsy, staging and treatment) are likely to be lower than those observed in voluntary, clinic-based screening programs.[18,36,37] At least 10% of the screening population will not be screened because of cardiovascular disease and other coexisting conditions.[5–7] Similarly, patterns of treatment may evolve over time, such that a greater or smaller proportion of men with screening-detected cancer cases will receive definitive surgical or radiation therapy.

Extrapolating from current incidence trends is more likely to represent the near future realistically, but some uncertainty surrounds these estimates as well. Data from Ontario, British Columbia and Saskatchewan indicate that PSA test use is either no longer increasing at the rate observed in the early 1990s (Ontario) or is levelling off (British Columbia and Saskatchewan). The incidence of prostate cancer in Ontario and several regions of the United States has fallen in recent years, after having peaked in 1992/93 (Cancer Care Ontario: unpublished data, 1997).[38,39] If the use of PSA testing and the incidence of screening-detected cancer level off, prostate cancer costs will increase more slowly than predicted by our scenario of annual exponential growth (at 8.2%).

Our study has limitations. The short time horizon is perhaps the most obvious of these. We describe only first-year costs of screening. Thus, costs for follow-up care for patients with true-positive and false-positive test results beyond the first year are not captured in our analysis. Neither are cost savings realized by prevention of metastatic disease and death. We do not regard this as a serious limitation, however, because published studies suggest that cost savings associated with prevention of advanced disease more than offset additional screening-associated costs.[40,41] First-year screening costs, therefore, represent an upper bound of net screening costs.

Other limitations include the fact that some estimates in our model (e.g., therapy for complications) are not derived from actual utilization data and that some cost data (e.g., radiation therapy) may not fairly represent costs in all provinces. However, we derived most estimates of resource use from empirical data, and a range of cost estimates is available for most items. Thus, we believe that

Table 5: Projected annual cost of nationwide PSA screening, diagnosis and treatment of prostate cancer in 1995 dollars*

	Scenario							
	Screening of all unscreened men aged 50–74 yr		Recurrent screening of men aged 50–74 yr		Recurrent screening of men aged 50–74 yr in 2005		Screening in 2000†	
Estimate	No. of cancers detected	Cost, $ million	No. of cancers detected	Cost, $ million	No. of cancers detected	Cost, $ million	No. of cancers detected	Cost, $ million
Baseline	82 999	317	29 837	163	39 925	219	14 184	66
Low		356		156		208		59
High		691		308		412		126

*Regional projections are available from the authors on request.
†Assuming existing trends in use of PSA screening and annual increase of 8.2% in incidence of sreening-detected cancer. See the Methods.

true costs are likely to be lower than our upper bound estimates for current and future costs of screening.

Descriptive costing studies have a limited role in policy development. We cannot, for example, draw any direct inferences about the appropriateness of present or future PSA screening from our findings. The appropriateness of any intervention must still be judged by the canon of efficacy, effectiveness and cost-effectiveness.[42–45] PSA screening has yet to be proven efficacious, effective or cost-effective. Defining the aggregate resource implications of health care interventions, however, is often a useful supplement to the canon and in practice may be one of the key factors in decisions regarding resource allocation. Our study contributes to the PSA screening debate by providing aggregate cost estimates for screening that are based for the most part on actual utilization data and representative costs.

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