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Prostate cancer with bone metastasis in Beijing: an observational study of prevalence, hospital visits and treatment costs using data from an administrative claims database

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ABSTRACT

Objectives To estimate the prevalence of prostate cancer with bone metastasis in Beijing, and to estimate hospital visits and direct treatment costs among male urban employees with the disease in Beijing.

Design Cross-sectional observational study.

Setting and participants Patients with prostate cancer and bone metastasis from the Urban Employee Basic Medical Insurance database covering the employed population of Beijing, China, from 2011 to 2014.

Primary and secondary outcome measures Prevalence, treatment costs and healthcare visits of patients with prostate cancer and bone metastasis.

Results A total of 1672 individuals were identified as having prostate cancer. Of these, 737 (44.1%) had bone metastasis, and among these, this was already present at the time of initial prostate cancer diagnosis in 27.0% (199/737). Mean age was 74.6 years (SD ±9.1). Prevalence of prostate cancer with bone metastasis increased from 5.3 per 100 000 males in 2011 to 8.3 per 100 000 males in 2014. The total annual health expenditure per patient (in 2014 American dollars) during the study period was $15 772.1 (SD=$16 942.6) ~$18 206.3 (SD=$18 700.2); 88% of these costs were reimbursed by insurance. Medication accounted for around 50% of total healthcare costs. Western drugs accounted for over 80% of medical costs with endocrine therapy being the most commonly prescribed treatment. There was an average 6.7% increase in expenditure related to diagnostical and therapeutical procedures over study years.

Conclusions The increase in the prevalence of prostate cancer with bone metastasis and associated healthcare costs in China reveals the growing clinical and economical burden of this disease. The high prevalence of bone metastasis among patients with prostate cancer seen in our study suggests that efforts may be needed to improve symptoms awareness and promote early help-seeking behaviour among the Chinese population.

Strengths and limitations of this study

- Our study is the first to estimate the prevalence of prostate cancer with bone metastasis in China.
- We used an administrative healthcare claims database of urban employees in Beijing in which the data were entered prospectively and therefore not subject to recall bias.
- The database included information from all cases of prostate cancer with bone metastasis treated in primary, secondary or tertiary hospitals therefore it is unlikely many cases will have been missed.
- Owing to the difference in age distribution between urban employees and the general male population of Beijing, prevalence estimates in this study could not be adjusted for age. Any future studies on this topic in populations with different age structures should bear this in mind if intending to make comparisons with our findings.

INTRODUCTION

Prostate cancer is the most common cancer in males in the developed world and a leading cause of cancer deaths.[1] In some less developed regions of the world – China, Brazil and Africa – incidence and mortality rates of prostate cancer have notably increased over recent decades.[2–4] In China, national cancer registration data show that between 1998 and 2008, the incidence of prostate cancer increased at an annual rate of 12.1%, and that in 2015, there were an estimated 60 300 new cases of prostate cancer.[3] This increase in incidence could be related to improved screening, ageing and changes in diet and other lifestyle factors.[5]

Prostate cancer will likely metastasise, especially to the bone, if not diagnosed and treated in the early stage of the disease.[6 7] Bone metastasis are painful and can cause pathological bone fracture, spinal cord compression and reduced mobility,[8] severely impacting on patients' quality of life[9] and representing a substantial economical burden.[10 11] Globally,

estimates of the prevalence of prostate cancer with bone metastasis are lacking. Published data are limited to a few studies reporting the proportion of prostate cancer cases with bone metastasis – 6.5% in the USA in 2004[11] and 6.8% in Thailand between 2006 and 2015.[12] Other data are limited to estimates of cumulative incidence of 11.5% in Denmark[13] and 18% to 29% in the USA[14] depending on follow-up duration.

After decades of effort and reform in the Chinese social health insurance system, medical insurance schemes are now well developed and administrative health databases have become a valuable resource for epidemiological and health economics research. The largest and most developed of these is the Urban Employee Basic Medical Insurance (UEBMI) claims database for employees in urban areas of China, which is administered by Beijing's medical insurance authorities.[15 16] Using data from the UEBMI, we aimed to estimate the prevalence of all prostate cancer and of prostate cancer with bone metastasis, as well as associated direct medical costs among the male population of Beijing between 2011 and 2014.

METHODS

Data source

The UEBMI database holds information from visits (inpatient and outpatient to all public healthcare facilities including primary, secondary and tertiary hospitals) of both active and retired employees covered by the urban employee basic medical insurance scheme in Beijing. Over 14 million employees have participated in the scheme and, by the end of 2014, its coverage had reached over 98%.[17] No identifying personal information such as full name, citizen's ID number and contact information is held. In addition to medical information, the data also include demographics (including sex, age, the city of residence and type of insurance), and all direct expenditure information. Medical data includes the type of visit, the name of the hospital, level of the hospital (primary, secondary or tertiary), the name of the department, date of visit, principal diagnoses, secondary diagnoses, diagnostical procedures and prescribed drugs/therapeutical agents prescribed (western drugs are coded by internationally recognised Anatomical Therapeutic Chemical Classification System). Expenditure data include total medical expenditure, amount paid by the UEBMI insurance, method of medical insurance settlement, the unit price of service and quantity of service, subtotal expenditure (defined as the total expenditure for the service in a certain visit, ie, unit price of service times quantity of service) and the proportion of insurance payment (defined as the proportion of the amount paid by the insurer in total amount due).

Study population and identification of prostate cancer patients

We identified all patients in the UEBMI with prostate cancer between 1 January 2011 and 31 December 2014 as individuals with International Classification of Diseases-10 (ICD-10) code C61 (malignant neoplasm of prostate) plus a free text entry indicating prostate cancer during this period. We subsequently identified those with ICD-10 code C79.5 (metastatic carcinoma of bone) plus a free text entry indicating bone metastasis in prostate cancer either on or following the initial prostate cancer diagnosis. The index date was set as the date of the first record of bone metastasis. In addition, all patients were required to have at least 6 months continuous enrolment with the insurance scheme before the index date.

Hospital visits and treatment costs

For each patient with prostate cancer and bone metastasis we identified all records of hospital visits for any reasons (termed 'all visits'). As patients with prostate cancer may visit hospital for reasons other than prostate cancer, visits directly related to the diagnosis or treatment of prostate cancer with bone metastasis were called 'valid visits'. These were identified from entries for ICD-10 codes C61 and C79.5 together with associated free text entries for prostate cancer and for bone metastasis in prostate cancer. We calculated annual medical care costs per hospital visit as well as per capita stratified by visit type (inpatient vs outpatient) and patient setting. The percentage of medical costs covered by UEBMI was also calculated. A separate cost analysis was conducted for total costs per capita. Total costs included all items eligible for reimbursement: drugs and diagnostical/therapeutical procedures. Medications were divided into western and Traditional Chinese Medicines (TCM). Western drugs were divided into four categories: radiotherapy drugs, chemotherapy drugs, hormone therapy drugs and bisphosphonates. Diagnostical and therapeutical procedures evaluated included examination, surgery, radiotherapy, inpatient stay, nursing care, medical device and other diagnostical fees. Traditional Chinese drugs were classified according to the Chinese Urological Association guideline (2014) for the treatment of prostate cancer.[18] We calculated the constituent ratio of both drugs and diagnostical/therapeutical items based on all visits. Costs in US dollars were calculated using the medical care component of the Consumer Price Index in China on December 2014[19] based on the average conversion rate of 6.1 ¥/US$ in 2014.[20]

Statistical analyses

We calculated the prevalence of prostate cancer (with or without metastasis) on 31 December of each study year by dividing the number of patients with prostate cancer and bone metastasis by the total number of males in the database at this time point, and expressed per 100 000 males. The denominator for the prevalence calculations was obtained from the annual government official report and statistical yearbook for the total population of male employees participating in the UEBMI. For hospital visits and treatment costs, data were described using frequencies and percentages for categorical variables, and means with SD and medians with IQR for continuous variables.

Table 1 Prevalence of prostate cancer with bone metastasis in Beijing from 2011 to 2014

Year	Number of urban employees covered (100 000s)	Number of males covered (100 000s)	Number of prostate cancer patients	Prevalence of prostate cancer per 100 000 males	Number of bone metastatic patients	Prevalence of bone metastasis per 100 000 males	Proportion of bone metastasis (%)
2011	118.8	61.1	971	15.9	322	5.3	33.2
2012	128.0	66.2	1138	17.2	459	7.0	40.3
2013	135.5	70.0	1227	17.5	561	8.0	45.7
2014	143.1	73.7	1286	17.5	611	8.3*	47.5*

*P value <0.001 for change over the study period.

The Student's t-test was applied to compare differences between groups for continuous variables. Analyses were conducted using SAS statistical software (V.9.2).

Patient and public involvement

There was no public or patient involvement in the conception of the research question or the design or implementation of the study.

RESULTS

A total of 1672 individuals were identified as having prostate cancer between 2011 and 2014. Of these, 737 (44.1%) had bone metastasis, – this was already present at the time of initial prostate cancer diagnosis in 27% (199/737). The mean age was 74.6 years (SD 9.1), and median age was 76 years (range 30 to 95 years). Three quarters of the patients were aged 70 years or more at first diagnosis of bone metastasis.

Prevalence

Table 1 shows the prevalence of prostate cancer with bone metastasis, as well as the proportion of all patients with prostate cancer who had bone metastasis in each study year. The prevalence of all prostate cancer was 15.9 per 100 000 males in 2011 rising to 17.5 per 100 000 males in 2014. The prevalence of prostate cancer with bone metastasis was 5.3 per 100 000 males in 2011, rising in each study year to 8.3 per 100 000 males in 2014 (p<0.001). Patients with bone metastases accounted for 33.2% of prostate cancer patients in 2011 increasing to 47.5% in 2014 (p<0.001).

Healthcare visits

Visits to medical institutions are shown in table 2. The total number of valid visits and all visits for the 4 years were 31 353 and 108 807, respectively. Eighty-nine per cent of valid visits were to tertiary hospitals compared with only 59.9% of all visits. The majority of hospital visits, both valid visits and all visits, were on an outpatient basis. However, the percentage of valid visits among all visits during the study period was three times higher for inpatient visits (75.1%) than for outpatient visits (25.0%). On average, patients had at least three hospital visits and 10 outpatient visits per year due to their bone metastasis.

Treatment costs

As shown in table 3, total, inpatient and outpatient costs among patients with prostate cancer and bone metastasis based on all visits increased across the study period. The mean cost of outpatient visits per capita rose from $5503.3 (SD $6137.7) in 2011 to $6844.8 (SD $6829.1) in 2014, while the mean cost of inpatient visits rose from $12 726.8 (SD $13 469.9) to $14 218.6 (SD $14 890.7) across study years. The percentage of outpatient and inpatient

Table 2 Distribution of hospital visits among patients with prostate cancer and bone metastasis

	Valid visits* (n, %)	All visits (n, %)
Medical institution		
Tertiary hospital	27 997 (89.3)	65 183 (59.9)
Secondary hospital	2669 (8.5)	14 518 (13.3)
Primary hospital	687 (2.2)	29 106 (26.8)
Total	31 353 (100.0)	108 807 (100.0)
Visits, time		
Outpatient		
2011	3298 (13.1)	13 025 (13.0)
2012	6112 (24.3)	24 193 (24.1)
2013	7612 (30.3)	31 121 (30.9)
2014	8131 (32.3)	32 215 (32.0)
Total	25 153 (100.0)	100 554 (100.0)
Inpatient		
2011	908 (14.6)	1140 (13.8)
2012	1417 (22.9)	1912 (23.2)
2013	1797 (29.0)	2432 (29.5)
2014	2078 (33.5)	2769 (33.5)
Total	6200 (100.0)	8253 (100.0)

*Visits directly related to the diagnosis or treatment of prostate cancer with bone metastasis.

Table 3 Total expenditure and reimbursement percentages for patients with prostate cancer and bone metastasis in Beijing from 2011 to 2014 (per patient per year)*

Year	Setting	N	Mean	SD	Median	Q1	Q3	%†
2011	Outpatient	310	5503.3	6137.7	3416.0	1609.6	6773.7	93.0%
	Inpatient	265	12726.8	13469.9	7536.3	3322.8	17701.0	87.4%
	Total	322	15772.1	16942.6	9360.2	4328.9	21147.6	89.3%
2012	Outpatient	447	6959.0	6976.3	4870.7	2389.5	8975.7	93.1%
	Inpatient	390	13745.0	15243.1	8551.3	3507.1	18323.3	88.0%
	Total	458	18496.2	18931.6	11704.7	5974.4	24070.1	89.9%
2013	Outpatient	552	6992.4	6990.6	4454.3	2137.9	8897.5	93.0%
	Inpatient	451	13555.3	14713.5	8411.0	3381.9	18909.8	87.9%
	Total	558	17873.3	18562.8	11144.6	4789.1	24630.8	89.9%
2014	Outpatient	599	6844.8	6829.1	4258.4	2439.7	8854.6	92.8%
	Inpatient	494	14218.6	14890.7	9529.8	4431.4	19005.0	86.0%
	Total	611	18206.3	18700.2	11801.0	5612.8	24711.6	88.5%

*Based on all visits. Q1 = 25% quartile/Q3 = 75% quartile.
†The proportion of treatment costs reimbursed by Urban Employee Basic Medical Insurance. SD, standard deviation.

treatment costs reimbursed by UEBMI during the study period was approximately 93% and 88%, respectively.

Among patients treated during our observation period, medications accounted for around half of total costs, with diagnostical and therapeutical procedures accounting for the other half. As shown in table 4, western drugs cost accounted for more than 80% of total medication costs, of which endocrine therapy drugs were the most frequently prescribed. Traditional Chinese drugs were used by most patients, while radiotherapy and chemotherapy were less frequently administered. Costs related to diagnostical and therapeutical procedures are shown in table 5. For each study year, over 98% of patients had at least one clinical examination. The mean costs of diagnostical and therapeutical procedures increased to $8858.0 in 2014 (a rise of 6.7% from 2011). Expenditures for examinations and medical devices per capita increased significantly over the study period while the annual output for radiotherapy and nursing care decreased ($p<0.001$).

DISCUSSION

Our study has revealed the growing burden of prostate cancer with bone metastasis in China. Using data from a large administrative claims database, we found that between 2011 and 2014, the prevalence of prostate cancer with bone metastasis among male urban employees of Beijing increased from 5.3 per 100 000 males to 8.3 per 100 000 males with a parallel increase in associated healthcare costs.

The main strength of our study is its novelty. We are unaware of other estimates of the prevalence of prostate cancer with bone metastasis worldwide, or of associated healthcare costs in China. Another strength is the large population-based data source representative of male urban employees in Beijing and including information on all healthcare visits whether to primary, secondary or tertiary institutions (where, in China, nearly all cancers are treated).[21] Our operational case definition required both a diagnosis of prostate cancer and of bone metastasis in prostate cancer (either concurrently or subsequently) together with free text entries indicative of both to minimise the number of false positives. However, we cannot exclude the possibility that some true cases may have been missed due to under-recording of relevant ICD-10 codes and/or the absence of free text entries, which could have led to underestimated prevalence estimates. A limitation of our study is that we were only able to calculate crude estimates of prostate cancer prevalence and not age-adjusted estimates because information on the age distribution of urban employees could not be obtained. Owing to the difference in age distribution between urban employees and the general population, our prevalence estimates cannot be generalised to all Chinese males, and all our study's findings are only generalisable to male employees in the city of Beijing. Any future studies on this topic in populations with different age structures should also bear this in mind if intending to make comparisons with our findings. Another limitation is that because date of death is not recorded in the UEBMI and the database is not linked to the city's death registry, we were unable to exclude patients who had died before 31 December in each study year in our prevalence calculations, and which would have led to some degree of underestimated prevalence estimates.

The proportion of patients with prostate cancer in our study who had bone metastasis – 33.2% in 2011, rising to 47.5% in 2014 – is much higher than reports from the USA (6.5%)[11] in the previous decade (2004) and from Thailand between 2006 and 2015.[12] This could be explained by recent advances in diagnostical methods, including the enhanced sensitivity of diagnostical tools enabling higher case detection, and developments in surgery,

Table 4 Medication costs among patients with prostate cancer and bone metastasis in Beijing from 2011 to 2014 (per patient per year)

Year (N)	2011 (n=322)		2012 (n=459)		2013 (n=561)		2014 (n=611)	
Medication	**N (%)**	**Mean; median (Q1, Q3)**	**N (%)**	**Mean; median (Q1, Q3)**	**N (%)**	**Mean; median (Q1, Q3)**	**N (%)**	**Mean; median (Q1, Q3)**
Western medication	322 (100.0%)	6736.8; 4172.8 (1909.6, 9381.7)	458 (99.8%)	7704.2; 4876.1 (2605.1, 10421.6)	558 (99.5%)	7197.4; 4586.0 (2192.8, 9655.7)	610 (99.8%)	7057.8; 4789.3 (2229.7, 9037.8)
Radiotherapy	16 (5.0%)	417.2; 1.0 (0.7, 30.2)	23 (5.0%)	305.2; 2.8 (0.8, 124.9)	12 (2.1%)	212.0; 0.9 (0.6, 6.9)	23 (3.8%)	220.7; 5.5 (1.2, 16.1)
Chemotherapy	56 (17.4%)	84.6; 16.1 (4.4, 58.6)	94 (20.5%)	164.1; 23.8 (6.6, 71.1)	118 (21.0%)	92.8; 23.6 (6.6, 54.4)	124 (20.3%)	89.7; 21.8 (7.4, 83.7)
Endocrine therapy	277 (86.0%)	1304.1; 818.6 (3572.4, 24677.1)	399 (86.9%)	1512.8; 1070.4 (344.6, 2048.9)	472 (84.1%)	1505.8; 1039.8 (364.3, 2117.3)	500 (81.8%)	1481.0; 1036.7 (432.8, 1980.2)
Bisphosphonates	216 (67.1%)	335.9; 64.4 (7.9, 425.3)	282 (61.4%)	433.3; 114.7 (7.2, 564.5)	300 (53.5%)	433.9; 155.0 (13.0, 544.9)	294 (48.1%)	449.2; 180.5 (11.8, 641.0)
Traditional Chinese medication	310 (96.3%)	1623.1; 783.0 (244.4, 2099.6)	447 (97.4%)	1902.6; 1122.2 (360.3, 2600.5)	541 (96.4%)	1886.8; 1032.9 (330.6, 2584.3)	591 (96.7%)	1858.1; 1067.0 (362.6, 2548.0)
Total	322 (100.0%)	8299.3; 5076.5 (2335.7, 11191.3)	458 (99.8%)	9561.2; 6059.6 (3255.0, 12933.9)	558 (99.5%)	9026.8; 5693.6 (2817.8, 12784.8)	610 (99.8%)	8858.0; 5956.7 (2875.3, 11413.6)

Q1 = 25% quartile/Q3 = 75% quartile.

Table 5 Diagnostical and therapeutical costs related to patients with prostate cancer and bone metastasis in Beijing from 2011 to 2014 (per patient per year)

Diagnostical or therapeutical procedure	2011 (n=322)		2012 (n=459)		2013 (n=561)		2014 (n=611)	
	N (%)	Mean; median (Q1, Q3)	N (%)	Mean; median (Q1, Q3)	N (%)	Mean; median (Q1, Q3)	N (%)	Mean; median (Q1, Q3)
Examination	311 (96.6%)	2232.3; 1386.6 (616.7, 2913.4)	448 (97.6%)	2585.8; 1565.7 (655.9, 3612.6)	549 (97.9%)	2669.9; 1498.8 (517.2, 3537.1)	597 (97.7%)	2798.6; 1624.9 (648.5, 3712.0)
Surgery	141 (43.8%)	236.1; 90.0 (24.2, 320.7)	202 (44.0%)	242.0; 128.2 (27.0, 357.2)	236 (42.1%)	51.3; 194.8 (29.1, 407.5)	272 (44.5%)	246.4; 138.0 (25.6, 401.4)
Radiotherapy	30 (9.3%)	2393.6; 526.5 (263.3, 2988.8)	49 (10.7%)	2158.4; 530.3 (256.6, 3079.0)	37 (6.6%)	2070.0; 500.2 (333.5, 2600.9)	58 (9.5%)	1992.3; 491.8 (245.9, 2336.0)
Inpatient stay	268 (83.2%)	340.8; 169.5 (74.2, 402.0)	394 (85.8%)	339.6; 178.6 (69.4, 430.3)	459 (81.8%)	288.3; 138.4 (60.4, 342.1)	501 (82.0%)	293.2; 153.7 (72.8, 351.8)
Nursing care	267 (82.9%)	71.2; 43.8 (20.2, 98.5)	392 (85.4%)	70.8; 43.2 (17.7, 92.1)	452 (80.6%)	64.4; 36.8 (15.9, 84.1)	497 (81.3%)	65.2; 37.7 (18.7, 85.7)
Medical device	316 (98.1%)	1364.3; 386.4 (111.0, 1156.4)	452 (98.5%)	1613.7; 432.3 (136.8, 1476.4)	553 (98.6%)	1504.1; 411.6 (103.1, 1624.6)	605 (99.0%)	1661.7; 474.2 (127.9, 1594.2)
Total	317 (98.4%)	8161.7; 4557.9 (1921.8, 10 688.3)	457 (99.6%)	9234.3; 5600.6 (2422.3, 12 600.5)	555 (98.9%)	9119.4; 5435.1 (1948.5, 12 501.0)	606 (99.2%)	9565.3; 5880.9 (2525.4, 13 623.2)

Q1 = 25% quartile/Q3 = 75% quartile.

radiotherapy, chemotherapy and other supportive treatments, leading to increased survival.[22] Also, we had access to all medical visits occurring in primary, secondary or tertiary hospitals, thus having maximum opportunity to capture all cases of bone metastasis. Another possible reason could be lower awareness of prostate cancer symptoms among the Chinese population compared with other countries, or other reasons for delay in help-seeking, with medical attention often only sought after the development of serious, painful symptoms or bone fractures – among patients with bone metastasis in our study, over a quarter had their diagnosis of bone metastasis at the time of initial prostate cancer diagnosis.

Costs per capita for inpatient visits were consistently around double those for outpatient visits across the study period. Drug expenditure accounted for 68% of the total expenditure among these patients, and unsurprisingly was highest for hormone therapy – a known effective treatment in this patient population.[18 23 24] In China, TCM is widely used as adjuvant therapy in cancer treatment, and this was clearly shown in our study, where over 95% of patients received TCM, accounting for one-fifth of total treatment costs. The majority of visits (89%) among patient with prostate cancer (with or without bone metastasis) in our study were to tertiary hospitals. This might be explained by the status of unbalanced medical resource in China. Also, the value that patients give to the advantages of tertiary hospitals – specialised doctors, and better diagnostics and treatment options – may override any concerns over costs.

As the population continues to age and more sophisticated diagnostical and treatment methods are more widely implemented, China will likely see an increased prevalence of patients with prostate cancer and bone metastasis, although future studies will be needed to investigate this. The increasing clinical and economical burden will be an important knowledge for healthcare decision makers in the country. The higher proportion of patients with prostate cancer who have bone metastasis in this study (compared with other countries) suggests the need for public health awareness regarding symptom development and efforts to improve early help-seeking.

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Contributors LZ performed the statistical analysis and wrote the manuscript. LZ, YC, YP and SZ contributed to the study design, interpretation of the data and the discussion of the manuscript. JZ, WS, LX, MS, YS and JL contributed to the manuscript revise and provided clinical support. All the authors supplied critical revisions to the manuscript and gave approval of the final version of the manuscript to be published.

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Data sharing statement Extracted data that support the findings of this study are available from Beijing Municipal Health Insurance Bureau but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available from the authors upon reasonable request and with permission of Beijing Municipal Health Insurance Bureau.

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