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The prevalence of lower urinary tract symptoms suggestive of benign prostatic hyperplasia (LUTS/BPH) in China: results from the China Health and Retirement Longitudinal Study

The prevalence of LUTS/BPH in China

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ABSTRACT

Objective. Rapid population aging in China is increasing the prevalence of lower urinary tract symptoms suggestive of benign prostatic hyperplasia (LUTS/BPH) among older people and so does the economic burden. Related data in China is insufficient and warranted.

Design. Secondary analysis of a cohort sample.

Setting. A nationally representative cross-sectional survey—the China Health and Retirement Longitudinal Study (CHARLS) was conducted in 2011 in mainland China.

Participants. Community-based individuals were drawn from the CHARLS through multistage probability sampling. Overall, a total of 5888 participants were included in this study.

Outcome measures. Self-reported morbid state was obtained using a structured questionnaire. The weighted-prevalence of LUTS/BPH was estimated and stratified by age group, marital status, education levels, economic levels, residing areas and geographic regions. Multivariable weighted logistic regression was used to examine the association of socioeconomic status with the odds of BPH.

Results. The weighted overall prevalence of LUTS/BPH was 10.66% (95% confidence interval [CI], 9.36-12.12). Among individuals age over 70 years, the prevalence was 14.67% (95% CI, 11.80-18.09), which increased with aging (P<0.05). The prevalence of LUTS/BPH among subjects residing the urban areas was much higher at 13.55% (95% CI, 10.95-16.64) than those living in rural areas at 8.38% (95% CI, 6.90-10.15). The South-Central and South-West had the lowest prevalence of LUTS/BPH, and prevalence was highest among respondent participants living in the North-West region.

Conclusions. In this study, we found there was an increasing trend of prevalence with aging and the prevalence varied according to marital status, socioeconomic status and geographic regions.

Keywords LUTS/BPH; epidemiology; China

Strengths and limitations

- Our data is based on the CHARLS, a strict national population survey.
- Prevalence of LUTS/BPH in China is hard to estimate, because not only the huge population but also the diagnostic criteria.
- The CHARLS did not collect the data of weight and height, so we couldn't analyze the relationship of BMI and prevalence of LUTS/BPH, nor obesity with prevalence.
- Testicular androgens are required in the prostate for the development of BPH, which is known.

Benign prostatic hyperplasia (BPH) is one of the most common diseases of mankind and represents a substantial disease burden. BPH is characterized by a proliferation of both stromal and epithelial cells of the prostate in the transitional zone surrounding the urethra (1). Approximately 50% of men >50 years of age will have pathological evidence of BPH, with this number increasing to >80% as men reach their eighth decade of life and older (2). And when men reach their age of 80, this number will increase to 83% (3). As the world population ages, the incidence and prevalence of BPH have rapidly increased (4). Lower urinary tract symptoms (LUTS) have been specified by the standardization subcommittee of the International Continence Society (ICS) in February 2002: "LUTS are the subjective indicators of a disease or change in conditions as perceived by the patients, carer or partners and may lead him/her to seek help from health care professionals. Symptoms may either be volunteered or described during the patient interview. They are usually qualitative" (5). But in 2006, Chapple and Roehrborn emphasized that the presence of LUTS does not need to be associated with the prostatic pathology only (6). Thus, LUTS/BPH was used in our study to refer to the symptomatic BPH. Although it is not life-threatening, LUTS/BPH is associated with serious morbidities and decreases of life quality (7,8). In America, LUTS/BPH affects more than 20% of American men aged 30 to 79 years, or roughly 15 million men (9,10). To data, the prevalence of BPH in China is mostly from autopsy and few of the studies based on the general population, which cannot reflect the actual situation of the disease (11). And no study has been conducted for LUTS/BPH in China. Thus, there is a paucity of data on prevalence of LUTS/BPH and its potential risk factors among the elderly in China.

China is a large country with a population of 1.3 billion. Of them, 25.3% were aged 50 years or older and 13.26% were greater than 60 years old (12). The project team filed an ethical review application to Ethical Review Committee (IRB) at Peking University in June 2008. The aging of the general population means that elderly people now account for a much greater proportion of patients with BPH. Many modifiable risk factors play roles in pathogenesis of BPH, including sex steroid hormones, the metabolic syndrome and cardiovascular disease, obesity, diabetes, diet, physical activity and inflammation. These risk factors cause a large variation of prevalence of LUTS/BPH in the different regions of China. Epidemiological studies comparing prevalence of LUTS/BPH according to age, socioeconomic status and geographic region by the same research

method will provide reliable estimates on the understanding of potential risk factors of LUTS/BPH and help for health care plan.

Using data collected from the China Health and Retirement Longitudinal Study (CHARLS), a national random sample of the Chinese population (13), we estimated the prevalence of LUTS/BPH among residents aged 50 years or older in China according to age, marital status, education levels, geographic region and socioeconomic status.

METHODS

The CHARLS is a survey of the elderly in China, based on a sample of households with members aged 45 years or above and their spouses. Data on the social-economic and health status were collected using standardized questionnaire (13). The baseline survey was conducted in 2011~2012 covering 450 villages/urban communities in 28 provinces. Eligible individuals were selected through four-stage, stratified, cluster sampling. Probabilities proportional to size (PPS) sampling was used in the decision of sample size. Detailed descriptions were provided in the previous publication (14).

Definitions of LUTS/BPH

BPH is a term used and reserved for the typical histological pattern which defines the disease. However, many men with histological BPH will never seek for medical care nor do they need any treatment for it. The condition goes differently when it is associated with LUTS. Individuals with histologic BPH visit a doctor only when LUTS occurs. Residents, participated in CHARLS and answered positively to the question whether have ever been diagnosed with a prostate illness (excluding prostatic cancer), were symptomatic firstly and diagnosed with BPH. We defined a subject as a LUTS/BPH if he responded positively to this question.

Data collection and grouping

The households were selected randomly and age-eligibly. All participants had a face-to-face household-interview using a structured questionnaire. Information collected during the household-interview included demographic factors, socioeconomic status and medical history.

Subjects were grouped into 3 strata according to age: 50-59, 60-69 and ≥70 years old. The

marital status was divided into married and unmarried/separated/widowed. Education level was divided into 5 categories: no formal education, elementary school, middle school, high school and college degree or above. Geographic region was divided into rural and urban. The economic level is defined according to the tertile of GDP. We categorized their living localities into six regions, i.e., East (7 provinces: Shandong, Jiangsu, Shanghai, Zhejiang, Fujian, Anhui, Jiangxi), North (2 cities: Beijing and Tianjin and 3 provinces: Hebei, Shanxi and Inner Mongolia), North-East (3 provinces: Liaoning, Jilin and Heilongjiang), North-West (4 provinces: Shaanxi, Gansu, Qinghai and Xinjiang), South-Central (5 provinces: Henan, Hubei, Hunan, Guangdong and Guangxi), and South-West (1 city: Chongqing and 3 provinces: Sichuan, Guizhou and Yunnan). Individuals living in Hainan, Ningxia, Taiwan and Tibet were not selected in this survey.

Statistical analyses

We used Stata to calculate the overall and age-specific prevalence of LUTS/BPH according to strata for each factor. The svy: logistic procedure in Stata version 14.2 was used to examine the association between each risk factor and the prevalence of BPH, adjusting for other potential confounders including sex, age, area, education, GDP per capita, and region. Both procedures took into account the complex survey design and the non-response rate for the CHARLS survey when estimating the prevalence, prevalence odds ratio (OR), and corresponding standard errors.

RESULTS

A total of 5,888 participants were involved in our study and the characteristics of the baseline population are given in Table 1. Five hundred and ninety-nine responded positively. Mean age was 62.78 (standard deviation: 8.56). Most of the participants were married. About a quarter of the participants didn't receive formal education and half of the rest received elementary or middle school education. The majority of the respondent participants lived in rural areas. About one third of respondent characteristics accounted respectively for the three various levels of GDP per capita.

The weighted overall prevalence of LUTS/BPH was 10.66% (95% confidence interval [CI]: 9.36, 12.12). The weighted results were in Table 2.

Age

Aging men were more likely to be diagnosed with LUTS/BPH, and the weighted prevalence of LUTS/BPH increased with age. Compared with subjects age <60 years, the adjusted odds ratio (OR) for the prevalence of LUTS/BPH were 1.50 (95% CI : 1.20, 1.87) for those age 60-69 years and 2.09 (95% CI: 1.58, 2.78)for those age ≥70 years (Table 3).

Marital status

The prevalence of LUTS/BPH was slightly higher among married individuals, at 10.80% (95% CI: 9.61, 12.12) while the prevalence among unmarried/separated/widowed individuals was 9.87% (95% CI: 6.56, 14.60). The odds of LUTS/BPH in unmarried/separated/widowed individuals was approximately 0.91 that in married individuals.

Education and economic levels

Variation in the prevalence of LUTS/BPH existed among different education and economic levels. Prevalence was much higher among individuals with more years-education and it was highest among individuals with education of college degree or above (P<0.05). The prevalence of LUTS/BPH was lower among individuals with a low GDP per capita.

Residing areas and regions

The prevalence of LUTS/BPH was higher among subjects residing in urban areas (rural: 8.38% [95% CI: 6.90, 10.15]; urban: 13.55% [95% CI: 10.95, 16.64]). The odds of LUTS/BPH in urban residents was 1.5 times that in rural residents. There was a significant difference in the prevalence of LUTS/BPH according to geographic location. The South-Central and South-West had the lowest prevalence of LUTS/BPH (9.76% and 9.53%, respectively), followed by the East (10.56%), North (12.18%), North-East (12.24%) regions; prevalence was highest among respondent participants living in the North-West region (13.75%). Compared with the East region, the ORs for LUTS/BPH for the North, North-East, North-West, South-Central, South-West regions were 1.12 (95% CI: 0.75, 1.67), 1.03 (95% CI: 0.76, 1.39), 1.66 (95% CI: 1.12, 2.47), 0.90 (95% CI: 0.53, 1.55), 1.01 (95% CI: 0.66, 1.53), respectively, after adjustment for age, marital status, rural/urban area, education and GDP per capita (Table 3). The prevalence of each regions can be seen in figure 1.

DISCUSSION

The CHARLS set up a high quality, nationally representative and publicly available micro-database, providing a wide range of information about the households of the elderly and also individual information on the elderly respondents and their spouses. Our research is based on data from the CHARLS. It was known by our research that LUTS/BPH was common among Chinese men age over 50 years. Age had great influence on prevalence of LUTS/BPH from both of our research and previous researches (15).

Rapid population aging in China is increasing the prevalence of LUTS/BPH among older people and so does the economic burden. In our research, adjusted prevalence of LUTS/BPH among men age beyond 50 years reached 10.66% (95% CI: 9.36, 12.12), which could influent on their life quality and bring economic burden on both individuals and society. It was believed that the cost of intervention and treatment of BPH is comprised of direct costs (drugs, procedures, imaging, office visits), indirect costs (lost earnings) and intangible costs (pain and suffering) (16). It is impartial that the costs for LUTS/BPH will continuously increase in the future. Thus, a prevalence study on LUTS/BPH will help formulate policy on public health.

As definition of BPH varies, the prevalence varies (17). When responding positively to whether have ever been diagnosed with a benign prostate illness, individual meant that some symptoms of LUTS has happened to him, and he sought for medical care and been diagnosed with a benign prostate illness. Benign prostate illness mainly refers to prostatitis and BPH, which shared a lot of overlap of symptoms. Prostatitis without BPH is a diagnosis of young men, but inflammation in the prostate is also observed in elderly men presenting with BPH. Qian XQ et al (18) clarified that histological prostatitis has affected the clinical progression of BPH because of the inflammation progress. Inflammation is the modifiable risk factors in BPH pathogenesis (15). Patients presenting with BPH may have a component of category IV, asymptomatic prostatitis (19). Thus, in our research, individuals, age over 50 years, responding positively to the question whether have been diagnosed with a benign prostate illness were counted as LUTS/BPH.

BPH increases with age, which has been confirmed by numerous researches. Loeb s et al (20) enrolled 278 men from the Baltimore Longitudinal Study of Aging, reported that the median rate of volume change was 0.6cc per year (range -9.9 to 62.1), corresponding to a median growth rate

of 2.5% per year (range -29.2 to 176.4%). The study was based on autopsy. Although the prostate volume isn't related to LUTS severity directly, it is a risk factor for it. Claus G et al (21) verified that larger prostate is associated with increased risks of urinary retention, increased future need for surgery and clinical progression of BPH. Another study, after following up for 16 years, also examined the increased incidence and progression of LUTS in men with age, significantly (22). In our research, LUTS/BPH involved symptoms of LUTS and histological BPH. Individuals age 60-69 years and ≥70 years has a much higher prevalence of LUTS/BPH, and the adjusted ORs were 1.5 (95% CI: 1.20, 1.87) and 2.09 (95% CI: 1.58, 2.78) respectively, compared with subjects age <60 years ($p<0.05$).

Studies about sex steroid hormones and BPH revealed that androstanediols play a role in BPH development (23). Unmarried/separated/widowed individuals accounted 13.20% in all the respondent participants, having a lower adjusted prevalence of LUTS/BPH at 9.87% (95% CI: 6.56, 14.60). These people were usually thought have no or less sexual life compared with married men. And married men intended more to visit doctor in case of their illness having a negative impact on their spouse and family.

In several studies, socioeconomic status played an important role in progression of LUTS/BPH and might vary the results particularly the prevalence and effects of LUTS/BPH (24). For example, some researchers found higher rates of BPH in upper income groups, but this may due to selection bias, because of higher utilization of medical care (25,26). Using data of Korean Community Health Survey performed in 2011, Jo KJ et al made a point that the severity of LUTS was associated with several socioeconomic factors, including education level, income level, living environment (27). Fowke JH et al confirmed that education of college or more had a lower IPSS score (28). Education levels were obtained when people were young, and kept changeless as aging. It influenced mainly the understanding of disease and decision-made progress. In our research, we analyzed socioeconomic factors including GDP per capita, education levels and geographic region. Individuals with education of college degree or above had a high adjusted OR of LUTS/BPH at 2.67 (95% CI: 1.57, 4.54) ($P<0.05$). And individuals residing in the urban areas was 1.5 times to these in rural. We considered that there was inevitable selection bias, as residents living in urban may seek medical care more often than these in rural. Some individuals lack the recognition about BPH and hospital visitation is often delayed.

We demonstrated an apparent geographic variation in the prevalence of LUTS/BPH in China. Residents in the South-West regions had a much lower prevalence of LUTS/BPH than those living in the North-West regions of China. Individuals residing in the north regions, including North, North-East and North-West, had a relatively higher prevalence of LUTS/BPH than those living in South-Central and South-West. The diet difference may contribute mainly to this discrimination. Daily diet of individuals living in north regions contained a lot of milk, dairy product and red meat, while individuals living in south regions enjoyed much more fruits and vegetables than those in north, which have both been confirmed to increase the risk of LUTS/BPH (29,30). But residents in East region didn't show a high prevalence of LUTS/BPH. It was considered that socioeconomic development in the East region was, in general, higher than that in other regions, which may contribute to the lower prevalence of LUTS/BPH. Besides that mentioned above, the genetic susceptibility of BPH was also a factor influencing the prevalence of LUTS/BPH in China. Several studies from China reported genetics associated with developing BPH (30), which may be one of the factors causing various prevalence of LUTS/BPH in China.

Our research has several strengths. First, our data is based on the CHARLS, a national population survey. The interviewers were trained strictly and questionnaires were developed over a long and rigorous course. The participants were chosen via strict multistage probability sampling procedure. Hence, data from the CHARLS can describe the national condition. Secondly, prevalence of LUTS/BPH in China is hard to estimate, because not only the huge population but also the diagnostic criteria. Using data from the CHARLS, we avoided both of the questions.

There are still some deficiencies as well. Firstly, the CHARLS did not collect the data of weight and height, so we couldn't analyze the relationship of BMI and prevalence of LUTS/BPH, nor obesity with prevalence. Secondly, testicular androgens are required in the prostate for the development of BPH, which is known. Thirdly, as China is a wide country, although we obey to the same principles of diagnosis from China Urology Association (CUA), the diagnosis of LUTS/BPH may be slightly different among regions. We cannot be aware of that, since the data of CHARLS gives an established diagnosis.

In this study, we looked at the prevalence of LUTS/BPH via the CHARLS data. We found that the LUTS/BPH is highly prevalent in older, urban-living men. And the prevalence varied according to marital status, socioeconomic status and geographic regions.

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Competing interest statement

None declared.

Author statement

Weiyu Zhang, Hao Hu: Designed the study and drafted the article

Haibin Li, Feng Wu: Dealt with the statistics

Xiaopeng Zhang, Huanrui Wang, Meishan Zhao: help with data sorting, literature retrieve, language polish and other chores

Kexin Xu: Constructive revision and grasp of the overall situation

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Table 1 The baseline of population

Characteristic	Men (n=5888)
Age, mean (SD)	62.78 (8.56)
Age group, No. (%)	
50-59	2356 (40.01)
60-69	2250 (38.21)
≥70	1282 (21.77)
Marital status, No. (%)	
Married	5111 (86.80)
Unmarried/Separated /Widowed	777 (13.20)
Education levels, No. (%)	
No formal education	1918 (32.84)
Elementary school	1573 (26.93)
Middle school	1426 (24.42)
High school	556 (9.52)
College degree or above	367 (6.28)
Geographic region, No. (%)	
Rural	3742 (63.55)
Urban	2146 (36.45)
GDP per capita, No. (%)	
Low	2114 (35.90)
Middle	1960 (33.29)
High	1814 (30.81)
Region, No. (%)	
East	2506 (42.56)
North	779 (13.23)
North-East	404 (6.86)
North-West	224 (3.80)
South-Central	974 (16.54)
South-West	1001 (17.00)

Table 2 The weighted prevalence

Characteristic	Case, No. (%)	Prevalence (%)	95% CI
Total	599 (10.17)	10.66	9.36-12.12
Age group, No. (%)			
50-59	182 (7.72)	8.39	7.01-9.98
60-69	236 (10.49)	10.61	8.67-12.91
≥70	181 (14.12)	14.67	11.80-18.09
Marital status, No. (%)			
Married	522 (10.21)	10.80	9.61-12.12
Unmarried/Separated /Widowed	77 (9.91)	9.87	6.56-14.60
Education levels, No. (%)			
No formal education	162 (8.45)	8.20	6.54-10.23
Elementary school	166 (10.55)	10.69	8.20-13.83
Middle school	130 (9.12)	9.17	6.71-12.40
High school	55 (9.89)	13.99	7.62-24.29
College degree or above	84 (22.89)	21.26	13.55-31.73
Geographic region, No. (%)			
Rural	328 (8.77)	8.38	6.90-10.15
Urban	271 (12.63)	13.55	10.95-16.64
GDP per capita, No. (%)			
Low	203 (9.60)	10.69	8.20-13.83
Middle	232 (11.84)	11.54	10.09-13.16
High	164 (9.04)	9.83	7.44-12.88
Region, No. (%)			
East	244 (9.74)	10.56	8.68-12.81
North	98 (12.58)	12.18	8.63-16.92
North-East	42 (10.40)	12.24	9.11-16.25
North-West	29 (12.95)	13.75	9.92-18.75
South-Central	91 (9.34)	9.76	6.47-14.45
South-West	95 (9.49)	9.53	6.24-14.31

Table 3 The adjusted odds ratio (OR) for the prevalence of LUTS/BPH

Characteristic	Crude OR (95 % CI)	Adjusted OR (95 % CI)	*P* value
Age group, No. (%)			
50-59	1.00 (reference)	1.00 (reference)	
60-69	1.29 (0.98-1.71)	1.50 (1.20-1.87)	0.001
≥70	1.87 (1.31-2.69)	2.09 (1.58-2.78)	0.000
Marital status, No. (%)			
Married	1.00 (reference)	1.00 (reference)	
Unmarried/Separated /Widowed	0.90(0.59-1.38)	0.91 (0.63-1.30)	0.597
Education levels, No. (%)			
No formal education	1.00 (reference)	1.00 (reference)	
Elementary school	1.34 (0.95-1.88)	1.36 (0.97-1.91)	0.074
Middle school	1.12 (0.79-1.61)	1.30 (0.93-1.82)	0.120
High school	1.82 (0.84-3.92)	2.27 (1.03-4.99)	0.043
College degree or above	3.02 (1.67-5.43)	2.67 (1.57-4.54)	0.000
Geographic region, No. (%)			
Rural	1.00 (reference)	1.00 (reference)	
Urban	1.71 (1.24-2.36)	1.50 (1.71-1.92)	0.002
GDP per capita, No. (%)			
Low	1.00 (reference)	1.00 (reference)	
Middle	1.08(0.77-1.53)	1.23 (0.94-1.62)	0.130
High	0.91(0.58-1.42)	0.99 (0.69-1.42)	0.958
Region, No. (%)			
East	1.00 (reference)	1.00 (reference)	
North	1.17 (0.74-1.84)	1.12 (0.75-1.67)	0.578
North-East	1.18 (0.77-1.79)	1.03 (0.76-1.39)	0.844
North-West	1.35 (0.86-2.11)	1.66 (1.12-2.47)	0.012
South-Central	0.91 (0.55-1.51)	0.90 (0.53-1.55)	0.696
South-West	0.89 (0.53-1.50)	1.01 (0.66-1.53)	0.970

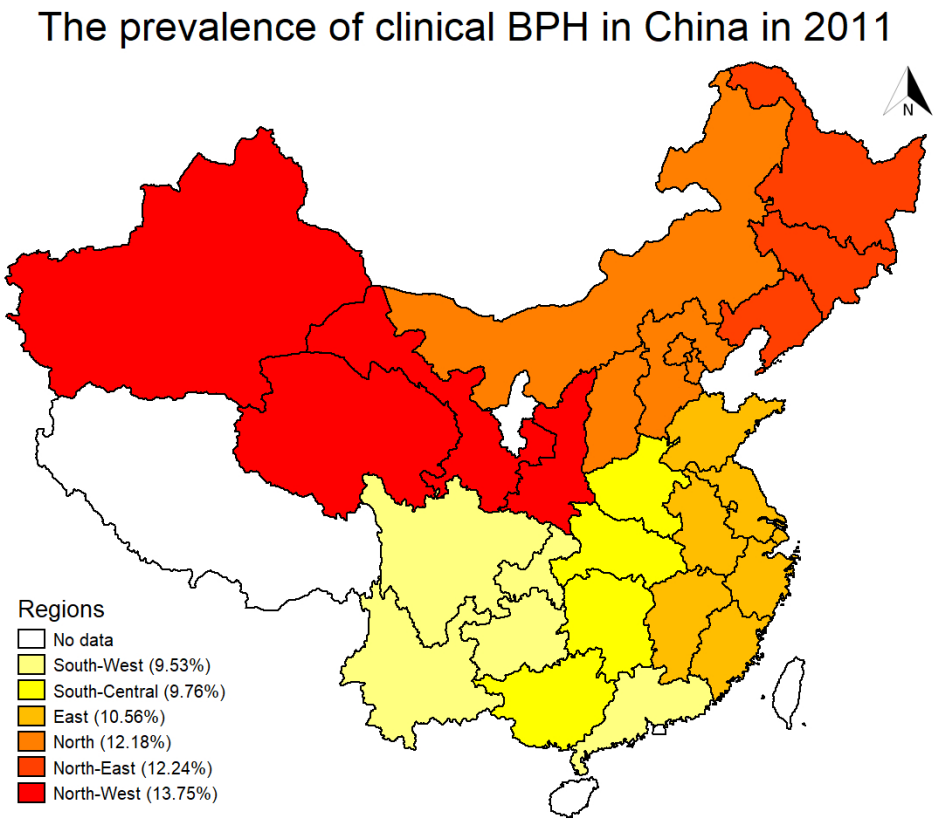

Figure 1. The prevalence of LUTS/BPH in each regions

403x331mm (72 x 72 DPI)

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The prevalence of lower urinary tract symptoms suggestive of benign prostatic hyperplasia (LUTS/BPH) in China: results from the China Health and Retirement Longitudinal Study

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The prevalence of lower urinary tract symptoms suggestive of benign prostatic hyperplasia (LUTS/BPH) in China: results from the China Health and Retirement Longitudinal Study

The prevalence of LUTS/BPH in China

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ABSTRACT

Objective. Rapid population aging in China is increasing the prevalence of lower urinary tract symptoms suggestive of benign prostatic hyperplasia (LUTS/BPH) among older people. The associated economic burdens are increasing as well. Relevant data from China is currently insufficient.

Design. Secondary analysis of a cohort sample.

Setting. A nationally representative cross-sectional survey—the China Health and Retirement Longitudinal Study (CHARLS) was conducted in 2011 in mainland China.

Participants. Individuals in the community selected from the CHARLS by multistage probability sampling. A total of 5888 participants aged 50 years and above were included.

Outcome measures. Self-reported morbid state was derived from a structured questionnaire. The weighted-prevalence of LUTS/BPH was estimated and stratified by age group, marital status, education levels, economic levels, residential areas and geographic regions. Multivariable weighted logistic regression was used to examine the association of socioeconomic status with the odds of BPH.

Results. The weighted overall prevalence of LUTS/BPH was 10.66% (95% confidence interval [CI], 9.36-12.12). Among individuals age over 70 years, the prevalence was 14.67% (95% CI, 11.80-18.09), and it increased with aging (P<0.05). The prevalence of LUTS/BPH among subjects residing the urban areas was higher [13.55% (95% CI, 10.95-16.64)] than those living in rural areas [8.38% (95% CI, 6.90-10.15)]. The prevalence of LUTS/BPH was lowest in the South-Central and South-West and highest the North-West region.

Conclusions. We found an increasing trend of prevalence of LUTS/BPH with aging. It varied according to marital status, socioeconomic status and geographic region.

Keywords LUTS/BPH; epidemiology; China

Strengths and limitations

- Our data is based on the CHARLS, a strict national population survey.
- Prevalence of LUTS/BPH in China is difficult to estimate, not only because of the large population but also because of the diagnostic criteria.
- The CHARLS did not collect weights and heights, so we could not analyze the relationship of BMI and obesity with prevalence of LUTS/BP
- Testicular androgens are required in the prostate for the development of BPH.

Benign prostatic hyperplasia (BPH) is a common disease of men, representing a substantial disease burden. BPH is characterized by a proliferation of both stromal and epithelial cells of the prostate in the transitional zone surrounding the urethra (1). Approximately 50% of men >50 years of age have pathological evidence of BPH, increasing to >80% as men reach their eighth decade of life and older (2). When men reach 80 years, this number increases to 83% (3). As the world population aged, the incidence and prevalence of BPH have rapidly increased (4). Lower urinary tract symptoms (LUTS) have been specified by the standardization subcommittee of the International Continence Society (ICS) in February 2002: "LUTS are the subjective indicators of a disease or change in conditions as perceived by the patients, carer or partners and may lead him/her to seek help from health care professionals. Symptoms may either be volunteered or described during the patient interview. They are usually qualitative" (5). However, in 2006, Chapple and Roehrborn emphasized that the presence of LUTS does not need to be associated with prostatic pathology only (6). Therefore, LUTS/BPH in our study referred to symptomatic BPH. Although it is not life-threatening, LUTS/BPH is associated with serious morbidities and decreases quality of life (7,8). In America, LUTS/BPH affects more than 20% of American men aged 30 to 79 years, or roughly 15 million men (9,10). The prevalence of BPH in China is currently determined from autopsy data and a few studies based on the general population that cannot accurately reflect the current status of the disease (11). No study has been conducted for LUTS/BPH in China. Therefore, there is a paucity of data regarding prevalence of LUTS/BPH and its potential risk factors among the elderly in China.

China has a population of 1.3 billion, 25.3% aged 50 years or older and 13.26% aged more than 60 years (12). The aging of the general population means that elderly people now account for a much greater proportion of patients with BPH. Many modifiable risk factors play roles in pathogenesis of BPH, including sex steroid hormones, the metabolic syndrome cardiovascular disease, obesity, diabetes, diet, physical activity and inflammation. These risk factors cause a large variation of

prevalence of LUTS/BPH in various regions of China. Epidemiological studies comparing prevalence of LUTS/BPH according to age, socioeconomic status and geographic region by the same research method will provide reliable estimates on the understanding of potential risk factors of LUTS/BPH and help design health care plans.

Using data collected from the China Health and Retirement Longitudinal Study (CHARLS), a national random sample of the Chinese population (13), we estimated the prevalence of LUTS/BPH among residents aged 50 years or older in China according to age, marital status, education levels, geographic region and socioeconomic status.

The project team filed an ethics review application to Ethical Review Committee (IRB) at Peking University in June 2008.

METHODS

The CHARLS is a survey of the elderly in China, based on a sample of households with members middle-aged and elderly and their spouses. Individuals aged 50 years and above were included in this study. Data on social-economic and health status were collected using standardized questionnaire (13). The baseline survey was conducted in 2011–2012 covering 450 villages/urban communities in 28 provinces. Eligible individuals were selected through four-stage, stratified cluster sampling. Probabilities proportional to size (PPS) sampling were used in the determination of sample size. Detailed descriptions were provided in a previous publication (14).

Definitions of LUTS/BPH

BPH is a term reserved for the typical histological pattern that defines the disease. However, many men with histological BPH never seek medical care, nor do they require treatment for it. The condition proceeds differently when it is associated with LUTS. Individuals with histologic BPH visit a doctor only when LUTS occurs. Residents who participated in CHARLS were asked whether they have ever been diagnosed

with a prostate illness (excluding prostatic cancer). We defined him as a subject with LUTS/BPH if he responded positively to this question.

Patient and Public Involvement

The households were selected randomly and age-eligibly. All participants had a face-to-face household-interview using a structured questionnaire. Information collected during the household-interview included demographic factors, socioeconomic status and medical history. The statistical analysis results will not disseminate to study participants in short time.

Subjects were grouped into 3 strata according to age: 50-59, 60-69 and ⩾70 years old. The marital status was divided into married and unmarried/separated/widowed. Education level was divided into 5 categories: no formal education, elementary school, middle school, high school and college degree or above. Geographic region was divided into rural and urban. The economic level were defined according to the tertile of GDP. We categorized their living localities into six regions, i.e., East (7 provinces: Shandong, Jiangsu, Shanghai, Zhejiang, Fujian, Anhui, Jiangxi), North (2 cities: Beijing and Tianjin and 3 provinces: Hebei, Shanxi and Inner Mongolia), North-East (3 provinces: Liaoning, Jilin and Heilongjiang), North-West (4 provinces: Shaanxi, Gansu, Qinghai and Xinjiang), South-Central (5 provinces: Henan, Hubei, Hunan, Guangdong and Guangxi) and South-West (1 city: Chongqing and 3 provinces: Sichuan, Guizhou and Yunnan). Individuals living in Hainan, Ningxia, Taiwan and Tibet were not selected in this survey.

Statistical analyses

We used Stata to calculate the overall and age-specific prevalence of LUTS/BPH according to strata for each factor. The svy: logistic procedure in Stata version 14.2 was used to examine the association between each risk factor and the prevalence of BPH, adjusting for other potential confounders including gender, age, area, education, GDP per capita, and region. Both procedures considered the complex survey design

and the non-response rate for the CHARLS survey when estimating the prevalence, prevalence odds ratio (OR), and corresponding standard errors.

RESULTS

A total of 5,888 participants were involved in our study and the characteristics of the baseline population are given in Table 1. Five hundred and ninety-nine responded positively. Mean age was 62.78 (standard deviation: 8.56). Most of the participants were married. About a quarter of the participants did not receive formal education and half of the rest received elementary or middle school education. The majority of the respondent participants lived in rural areas. About one third of respondents were classified in three levels of GDP per capita.

The weighted overall prevalence of LUTS/BPH was 10.66% (95% confidence interval [CI]: 9.36, 12.12). The weighted results are listed in Table 2.

Age

Aging men were more likely to be diagnosed with LUTS/BPH, and the weighted prevalence of LUTS/BPH increased with age. Compared with subjects age <60 years, the adjusted odds ratios (OR) for the prevalence of LUTS/BPH were 1.50 (95% CI: 1.20, 1.87) for those age 60-69 years and 2.09 (95% CI: 1.58, 2.78) for those aged ⩾70 years (Table 3).

Marital status

The prevalence of LUTS/BPH was slightly higher among married individuals, at 10.80% (95% CI: 9.61, 12.12) while the prevalence among unmarried/separated/widowed individuals was 9.87% (95% CI: 6.56, 14.60). The odds of LUTS/BPH in unmarried/separated/widowed individuals was approximately 0.91 times that of married individuals.

Education and economic levels

There was variation in the prevalence of LUTS/BPH among various education and economic levels. Prevalence was much higher among individuals with more years of education and it was highest among individuals with college degrees or above ($P < 0.05$). The prevalence of LUTS/BPH was lower among individuals with a low GDP per capita.

Resident areas and regions

The prevalence of LUTS/BPH was higher among subjects residing in urban areas (rural: 8.38% [95% CI: 6.90, 10.15]; urban: 13.55% [95% CI: 10.95, 16.64]). The odds of LUTS/BPH in urban residents was 1.5 times that of rural residents. There was a significant difference in the prevalence of LUTS/BPH according to geographic location. The South-Central and South-West had the lowest prevalence of LUTS/BPH (9.76% and 9.53%, respectively), followed by the East (10.56%), North (12.18%) and North-East (12.24%) regions; prevalence was highest among respondents living in the North-West region (13.75%). Compared with the East region, the ORs for LUTS/BPH for the North, North-East, North-West, South-Central, South-West regions were 1.12 (95% CI: 0.75, 1.67), 1.03 (95% CI: 0.76, 1.39), 1.66 (95% CI: 1.12, 2.47), 0.90 (95% CI: 0.53, 1.55) and 1.01 (95% CI: 0.66, 1.53), respectively, after adjustment for age, marital status, rural/urban area, education and GDP per capita (Table 3). The prevalence of each region can be seen in Figure 1.

DISCUSSION

The CHARLS set up a high quality, nationally representative, publicly available micro-database, providing a wide range of information regarding the households of the elderly as well as individual information on the elderly respondents and their spouses. Our research is based on data from the CHARLS. It was known from our study that LUTS/BPH was common among Chinese men age over 50 years. Age had great influence on prevalence of LUTS/BPH according to ours and other studies (15).

Rapid population aging in China is increasing the prevalence of LUTS/BPH among older people and so does the economic burdens associated with it. In our study, adjusted prevalence of LUTS/BPH among men aged beyond 50 years reached 10.66% (95% CI: 9.36, 12.12), which could influence their life quality and impose economic burdens on both individuals and society. The cost of intervention and treatment of BPH is comprised of direct costs (drugs, procedures, imaging, office visits), indirect costs (lost earnings) and intangible costs (pain and suffering) (16). It is likely that the costs for LUTS/BPH will continuously increase in the future. Therefore, a prevalence study on LUTS/BPH can help guide public health policy.

As definition of BPH varies, the prevalence varies (17). When responding positively to a question regarding diagnosis of a benign prostate illness, an individual means that some symptoms of LUTS occurred in him, and that he sought for medical care and was diagnosed with a benign prostate illness. Benign prostate illness primarily refers to prostatitis and BPH, which shared many overlapping symptoms. Prostatitis without BPH is a diagnosis of young men, however, inflammation in the prostate is also observed in elderly men presenting with BPH. Gandaglia et al. (18) suggested that histological prostatitis affected the progression of BPH because of the inflammatory process. Inflammation is a modifiable risk factor in BPH pathogenesis (15). Patients presenting with BPH may have a component of category IV, asymptomatic prostatitis (19). Thus, in our study, individuals over age 50 who responded positively to the question regarding diagnosis with a benign prostate illness were counted as having LUTS/BPH.

BPH increases with age, as has been confirmed by numerous studies. Loeb et al. (20) enrolled 278 men from the Baltimore Longitudinal Study of Aging and reported that the median rate of volume change was 0.6 cc per year (range -9.9 to 62.1), corresponding to a median growth rate of 2.5% per year (range -29.2% to 176.4%). The study was based on autopsy. Although prostate volume is not related to LUTS

severity directly, it is a risk factor. Roehrborn et al. (21) reported that larger prostate was associated with increased risks of urinary retention, increased future need for surgery and clinical progression of BPH. Another study, after follow-up for 16 years, reported significantly increased incidence and progression of LUTS in men with age (22). In our study, LUTS/BPH involved symptoms of LUTS and histological BPH. Individuals aged 60-69 years and ⩾70 years had a much higher prevalence of LUTS/BPH, and the adjusted ORs were 1.5 (95% CI: 1.20, 1.87) and 2.09 (95% CI: 1.58, 2.78) respectively, compared with subjects age <60 years ($p < 0.05$).

Studies of sex steroid hormones and BPH revealed that androstanediols play a role in BPH development (23). Unmarried/separated/widowed individuals accounted 13.20% in all the respondent participants, having a lower adjusted prevalence of LUTS/BPH at 9.87% (95% CI: 6.56, 14.60). These people are usually thought have no or less sexual life compared with married men. Married men more often intended to visit doctor in case of their illness would have a negative impact on their spouse and family.

In several studies, socioeconomic status played an important role in progression of LUTS/BPH and might vary the results, particularly the prevalence and effects of LUTS/BPH (24). For example, some researchers found higher rates of BPH in upper income groups, but this may due to selection bias, because of higher utilization of medical care (25,26). Using data from the Korean Community Health Survey performed in 2011, Jo KJ et al. found that the severity of LUTS was associated with several socioeconomic factors, including education level, income level and living environment (27). Fowke et al. found that college education or higher levels was associated with a lower IPSS score (28). Education levels were obtained when people were young, and did not change with aging. Nevertheless, education influenced the understanding of disease and the decision-making progress. In our study, we analyzed socioeconomic factors including GDP per capita, education levels and geographic region. Individuals with education of college degree or above had a high adjusted OR of LUTS/BPH at 2.67 (95% CI: 1.57, 4.54) (P<0.001). Individuals residing

in urban areas were 1.5 times more likely to have the diagnosis than those in rural areas. We believe that there was inevitable selection bias, as residents living in urban areas may seek medical care more often than do those in rural areas. Some individuals lack the recognition of BPH and hospital visitation is often delayed.

We demonstrated an apparent geographic variation in the prevalence of LUTS/BPH in China. Residents in the South-West regions had a much lower prevalence of LUTS/BPH than did those living in the North-West regions of China. Individuals residing in the north regions, including North, North-East and North-West, had a relatively higher prevalence of LUTS/BPH than did those living in South-Central and South-West. Dietary differences may contribute to this discrepancy. Daily diet of individuals living in north regions contain much milk, dairy products and red meat, while individuals living in south regions consume more fruits and vegetables than do those in the north, which have both been confirmed to increase the risk of LUTS/BPH (29,30). Nevertheless, residents in East region did not show a high prevalence of LUTS/BPH. It was thought that socioeconomic development in the East region was, in general, higher than that of other regions, possibly contributing to the lower prevalence of LUTS/BPH. Furthermore, the genetic susceptibility of BPH was also a factor influencing the prevalence of LUTS/BPH in China. Several studies from China reported genetics associated with developing BPH (30), possibly one of the factors causing varying prevalence of LUTS/BPH in China.

Our research has several strengths. First, our data was based on the CHARLS, a national population survey. The interviewers were highly-trained and questionnaires were developed after a long and rigorous course. The participants were chosen via strict multistage probability sampling procedures. Hence, data from the CHARLS can represent the national condition. Second, the prevalence of LUTS/BPH in China is difficult to estimate, not only because of the large population but also because of the diagnostic criteria. Using data from the CHARLS, we avoided both questions.

There are some limitations as well. First, the CHARLS did not collect weight and height, so we could not analyze the relationship of BMI or obesity and prevalence of LUTS/BPH. Second, testicular androgens are required in the prostate for the development of BPH. Third, as China is a large country, and we all adhere to the principles of diagnosis from the China Urology Association (CUA), the diagnosis of LUTS/BPH may be slightly different among regions. We cannot detect these differences, since the data of CHARLS provides an established diagnosis.

In this study, we looked at the prevalence of LUTS/BPH via CHARLS data. We found that the LUTS/BPH is highly prevalent in older, urban-living men. The prevalence varied according to marital status, socioeconomic status and geographic regions.

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Competing interest statement

None declared.

Author statement

Weiyu Zhang, Xiaopeng Zhang: Designed the study and drafted the article

Haibin Li, Feng Wu: Dealt with the statistics

Huanrui Wang, Meishan Zhao: help with data sorting, literature retrieve, language polish and other chores

Hao Hu, Kexin Xu: Constructive revision and grasp of the overall situation

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Data sharing statement

No additional unpublished data are available.

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Table 1 Baseline population characteristics

Characteristic	Men (n=5888)
Age, mean (SD)	62.78 (8.56)
Age group, No. (%)	
50-59	2356 (40.01)
60-69	2250 (38.21)
⩾70	1282 (21.77)
Marital status, No. (%)	
Married	5111 (86.80)
Unmarried/Separated /Widowed	777 (13.20)
Education levels, No. (%)*	
No formal education	1918 (32.84)
Elementary school	1573 (26.93)
Middle school	1426 (24.42)
High school	556 (9.52)
College degree or above	367 (6.28)
Geographic region, No. (%)	
Rural	3742 (63.55)
Urban	2146 (36.45)
GDP per capita, No. (%)	
Low	2114 (35.90)
Middle	1960 (33.29)
High	1814 (30.81)
Region, No. (%)	
East	2506 (42.56)
North	779 (13.23)
North-East	404 (6.86)
North-West	224 (3.80)
South-Central	974 (16.54)
South-West	1001 (17.00)

*, Education levels values of 48 cases was missed.

Table 2 Weighted prevalence

Characteristic	Case, No. (%)	Prevalence (%)	95% CI
Total	599 (10.17)	10.66	9.36-12.12
Age group, No. (%)			
50-59	182 (7.72)	8.39	7.01-9.98
60-69	236 (10.49)	10.61	8.67-12.91
⩾70	181 (14.12)	14.67	11.80-18.09
Marital status, No. (%)			
Married	522 (10.21)	10.80	9.61-12.12
Unmarried/Separated /Widowed	77 (9.91)	9.87	6.56-14.60
Education levels, No. (%)*			
No formal education	162 (8.45)	8.20	6.54-10.23
Elementary school	166 (10.55)	10.69	8.20-13.83
Middle school	130 (9.12)	9.17	6.71-12.40
High school	55 (9.89)	13.99	7.62-24.29
College degree or above	84 (22.89)	21.26	13.55-31.73
Geographic region, No. (%)			
Rural	328 (8.77)	8.38	6.90-10.15
Urban	271 (12.63)	13.55	10.95-16.64
GDP per capita, No. (%)			
Low	203 (9.60)	10.69	8.20-13.83
Middle	232 (11.84)	11.54	10.09-13.16
High	164 (9.04)	9.83	7.44-12.88
Region, No. (%)			
East	244 (9.74)	10.56	8.68-12.81
North	98 (12.58)	12.18	8.63-16.92
North-East	42 (10.40)	12.24	9.11-16.25
North-West	29 (12.95)	13.75	9.92-18.75
South-Central	91 (9.34)	9.76	6.47-14.45
South-West	95 (9.49)	9.53	6.24-14.31

*, Education levels values of 48 cases was missed.

Table 3 The adjusted odds ratio (OR) for the prevalence of LUTS/BPH

Characteristic	Crude OR (95 % CI)	Adjusted OR (95 % CI)	*P* value
Age group, No. (%)			<0.001
50-59	1.00 (reference)	1.00 (reference)	
60-69	1.29 (0.98-1.71)	1.50 (1.20-1.87)	0.001
⩾70	1.87 (1.31-2.69)	2.09 (1.58-2.78)	<0.001
Marital status, No. (%)			
Married	1.00 (reference)	1.00 (reference)	
Unmarried/Separated /Widowed	0.90(0.59-1.38)	0.91 (0.63-1.30)	0.597
Education levels, No. (%)			0.001
No formal education	1.00 (reference)	1.00 (reference)	
Elementary school	1.34 (0.95-1.88)	1.36 (0.97-1.91)	0.074
Middle school	1.12 (0.79-1.61)	1.30 (0.93-1.82)	0.120
High school	1.82 (0.84-3.92)	2.27 (1.03-4.99)	0.043
College degree or above	3.02 (1.67-5.43)	2.67 (1.57-4.54)	0.000
Geographic region, No. (%)			
Rural	1.00 (reference)	1.00 (reference)	
Urban	1.71 (1.24-2.36)	1.50 (1.71-1.92)	0.002
GDP per capita, No. (%)			0.156
Low	1.00 (reference)	1.00 (reference)	
Middle	1.08(0.77-1.53)	1.23 (0.94-1.62)	0.130
High	0.91(0.58-1.42)	0.99 (0.69-1.42)	0.958
Region, No. (%)			0.200
East	1.00 (reference)	1.00 (reference)	
North	1.17 (0.74-1.84)	1.12 (0.75-1.67)	0.578
North-East	1.18 (0.77-1.79)	1.03 (0.76-1.39)	0.844
North-West	1.35 (0.86-2.11)	1.66 (1.12-2.47)	0.012
South-Central	0.91 (0.55-1.51)	0.90 (0.53-1.55)	0.696
South-West	0.89 (0.53-1.50)	1.01 (0.66-1.53)	0.970

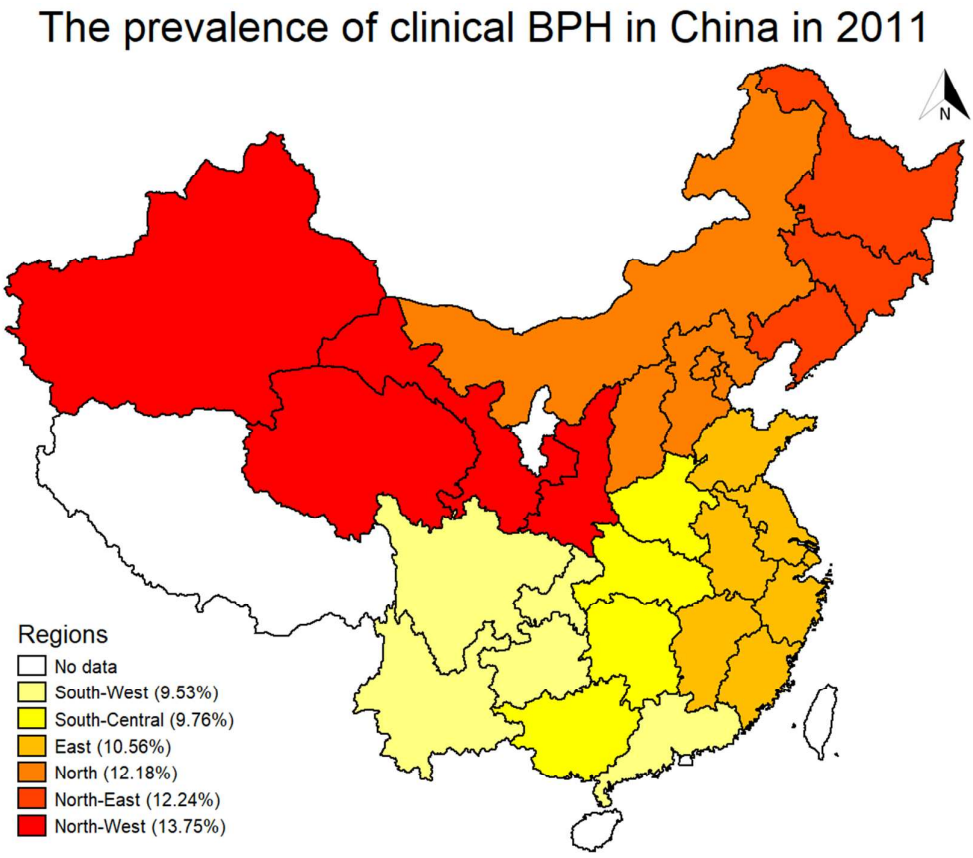

Figure 1 The prevalence of each region

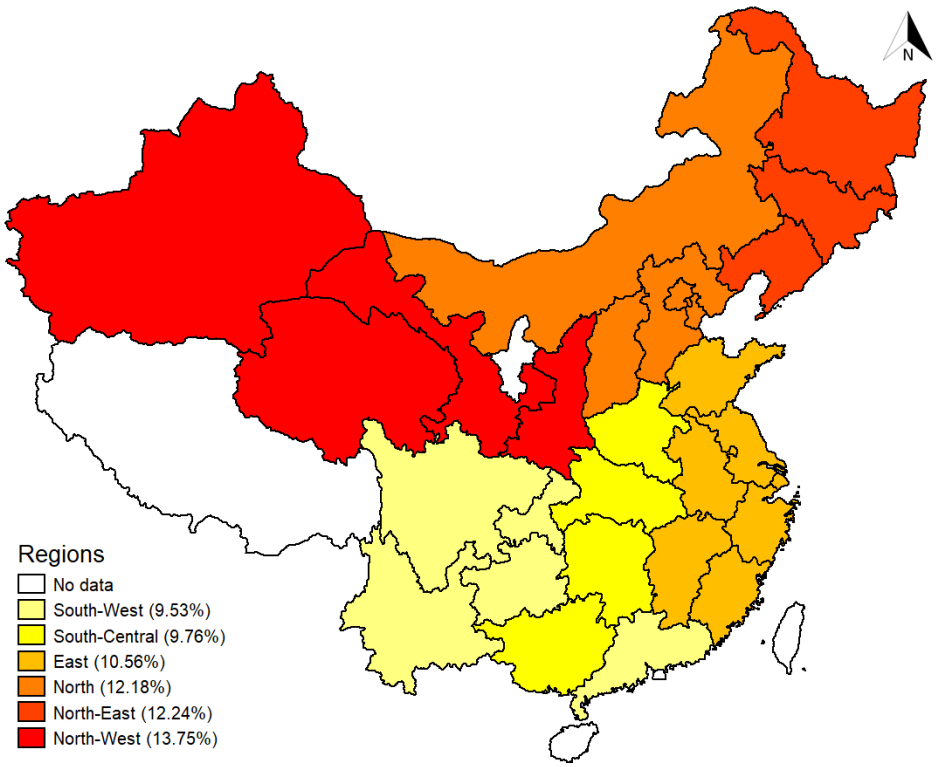

Figure 1. The prevalence of LUTS/BPH in each regions

403x331mm (72 x 72 DPI)

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The prevalence of lower urinary tract symptoms suggestive of benign prostatic hyperplasia (LUTS/BPH) in China: results from the China Health and Retirement Longitudinal Study

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The prevalence of lower urinary tract symptoms suggestive of benign prostatic hyperplasia (LUTS/BPH) in China: results from the China Health and Retirement Longitudinal Study

The prevalence of LUTS/BPH in China

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ABSTRACT

Objective. Rapid population aging in China is increasing the prevalence of lower urinary tract symptoms suggestive of benign prostatic hyperplasia (LUTS/BPH) among older people. The associated economic burdens are increasing as well. Relevant data from China is currently insufficient.

Design. Secondary analysis of a cohort sample.

Setting. A nationally representative cross-sectional survey—the China Health and Retirement Longitudinal Study (CHARLS) was conducted in 2011 in mainland China.

Participants. Individuals in the community selected from the CHARLS by multistage probability sampling. A total of 5888 participants aged 50 years and above were included.

Outcome measures. Self-reported morbid state was derived from a structured questionnaire. The weighted-prevalence of LUTS/BPH was estimated and stratified by age group, marital status, education levels, economic levels, residential areas and geographic regions. Multivariable weighted logistic regression was used to examine the association of socioeconomic status with the odds of BPH.

Results. The weighted overall prevalence of LUTS/BPH was 10.66% (95% confidence interval [CI], 9.36-12.12). Among individuals age over 70 years, the prevalence was 14.67% (95% CI, 11.80-18.09), and it increased with aging (P<0.05). The prevalence of LUTS/BPH among subjects residing the urban areas was higher [13.55% (95% CI, 10.95-16.64)] than those living in rural areas [8.38% (95% CI, 6.90-10.15)]. The prevalence of LUTS/BPH was lowest in the South-Central and South-West and highest the North-West region.

Conclusions. We found an increasing trend of prevalence of LUTS/BPH with aging. It varied according to marital status, socioeconomic status and geographic region.

Keywords LUTS/BPH; epidemiology; China

Strengths and limitations

- Our data is based on the CHARLS, a strict national population survey.
- Prevalence of LUTS/BPH in China is difficult to estimate, not only because of the large population but also because of the diagnostic criteria.
- The CHARLS did not collect weights and heights, so we could not analyze the relationship of BMI and obesity with prevalence of LUTS/BPH.

Benign prostatic hyperplasia (BPH) is a common disease of men, representing a substantial disease burden. BPH is characterized by a proliferation of both stromal and epithelial cells of the prostate in the transitional zone surrounding the urethra (1). Approximately 50% of men >50 years of age have pathological evidence of BPH, increasing to >80% as men reach their eighth decade of life and older (2). When men reach 80 years, this number increases to 83% (3). As the world population aged, the incidence and prevalence of BPH have rapidly increased (4). Lower urinary tract symptoms (LUTS) have been specified by the standardization subcommittee of the International Continence Society (ICS) in February 2002: "LUTS are the subjective indicators of a disease or change in conditions as perceived by the patients, carer or partners and may lead him/her to seek help from health care professionals. Symptoms may either be volunteered or described during the patient interview. They are usually qualitative" (5). However, in 2006, Chapple and Roehrborn emphasized that the presence of LUTS does not need to be associated with prostatic pathology only (6). Therefore, LUTS/BPH in our study referred to symptomatic BPH. Although it is not life-threatening, LUTS/BPH is associated with serious morbidities and decreases quality of life (7,8). In America, LUTS/BPH affects more than 20% of American men aged 30 to 79 years, or roughly 15 million men (9,10). The prevalence of BPH in China is currently determined from autopsy data and a few studies based on the general population that cannot accurately reflect the current status of the disease (11). No study has been conducted for LUTS/BPH in China. Therefore, there is a paucity of data regarding prevalence of LUTS/BPH and its potential risk factors among the elderly in China.

China has a population of 1.3 billion, 25.3% aged 50 years or older and 13.26% aged more than 60 years (12). The aging of the general population means that elderly people now account for a much greater proportion of patients with BPH. Many modifiable risk factors play roles in pathogenesis of BPH, including sex steroid hormones, the metabolic syndrome cardiovascular disease, obesity, diabetes, diet, physical activity and inflammation. These risk factors cause a large variation of

prevalence of LUTS/BPH in various regions of China. Epidemiological studies comparing prevalence of LUTS/BPH according to age, socioeconomic status and geographic region by the same research method will provide reliable estimates on the understanding of potential risk factors of LUTS/BPH and help design health care plans.

Using data collected from the China Health and Retirement Longitudinal Study (CHARLS), a national random sample of the Chinese population (13), we estimated the prevalence of LUTS/BPH among residents aged 50 years or older in China according to age, marital status, education levels, geographic region and socioeconomic status.

The project team filed an ethics review application to Ethical Review Committee (IRB) at Peking University in June 2008 and obtained approval.

METHODS

The CHARLS is a survey of the elderly in China, based on a sample of households with members middle-aged and elderly and their spouses. Individuals aged 50 years and above were included in this study. Data on social-economic and health status were collected using standardized questionnaire (13). The baseline survey was conducted in 2011–2012 covering 450 villages/urban communities in 28 provinces. Eligible individuals were selected through four-stage, stratified cluster sampling. Probabilities proportional to size (PPS) sampling were used in the determination of sample size. Detailed descriptions were provided in a previous publication (14).

Definitions of LUTS/BPH

BPH is a term reserved for the typical histological pattern that defines the disease. However, many men with histological BPH never seek medical care, nor do they require treatment for it. The condition proceeds differently when it is associated with LUTS. Individuals with histologic BPH visit a doctor only when LUTS occurs. Residents who participated in CHARLS were asked whether they have ever been

diagnosed with a prostate illness (excluding prostatic cancer). We defined him as a subject with LUTS/BPH if he responded positively to this question.

Data collection and grouping

The households were selected randomly and age-eligibly. All participants had a face-to-face household-interview using a structured questionnaire. Information collected during the household-interview included demographic factors, socioeconomic status and medical history. The statistical analysis results will not disseminate to study participants in short time.

Subjects were grouped into 3 strata according to age: 50-59, 60-69 and ⩾70 years old. The marital status was divided into married and unmarried/separated/widowed. Education level was divided into 5 categories: no formal education, elementary school, middle school, high school and college degree or above. Geographic region was divided into rural and urban. The economic level were defined according to the tertile of GDP. We categorized their living localities into six regions, i.e., East (7 provinces: Shandong, Jiangsu, Shanghai, Zhejiang, Fujian, Anhui, Jiangxi), North (2 cities: Beijing and Tianjin and 3 provinces: Hebei, Shanxi and Inner Mongolia), North-East (3 provinces: Liaoning, Jilin and Heilongjiang), North-West (4 provinces: Shaanxi, Gansu, Qinghai and Xinjiang), South-Central (5 provinces: Henan, Hubei, Hunan, Guangdong and Guangxi) and South-West (1 city: Chongqing and 3 provinces: Sichuan, Guizhou and Yunnan). Individuals living in Hainan, Ningxia, Taiwan and Tibet were not selected in this survey.

Patient and Public Involvement

Patients and/or public where not involved in the design or conduct of this study.

Statistical analyses

We used Stata to calculate the overall and age-specific prevalence of LUTS/BPH according to strata for each factor. The svy: logistic procedure in Stata version 14.2

was used to examine the association between each risk factor and the prevalence of BPH, adjusting for other potential confounders including gender, age, area, education, GDP per capita, and region. Both procedures considered the complex survey design and the non-response rate for the CHARLS survey when estimating the prevalence, prevalence odds ratio (OR), and corresponding standard errors.

RESULTS

A total of 5,888 participants were involved in our study and the characteristics of the baseline population are given in Table 1. Five hundred and ninety-nine responded positively. Mean age was 62.78 (standard deviation: 8.56). Most of the participants were married. About a quarter of the participants did not receive formal education and half of the rest received elementary or middle school education. The majority of the respondent participants lived in rural areas. About one third of respondents were classified in three levels of GDP per capita.

The weighted overall prevalence of LUTS/BPH was 10.66% (95% confidence interval [CI]: 9.36, 12.12). The weighted results are listed in Table 2.

Age

Aging men were more likely to be diagnosed with LUTS/BPH, and the weighted prevalence of LUTS/BPH increased with age. Compared with subjects age <60 years, the adjusted odds ratios (OR) for the prevalence of LUTS/BPH were 1.50 (95% CI: 1.20, 1.87) for those age 60-69 years and 2.09 (95% CI: 1.58, 2.78) for those aged $\geqslant$ 70 years (Table 3).

Marital status

The prevalence of LUTS/BPH was slightly higher among married individuals, at 10.80% (95% CI: 9.61, 12.12) while the prevalence among unmarried/separated/widowed individuals was 9.87% (95% CI: 6.56, 14.60). The

odds of LUTS/BPH in unmarried/separated/widowed individuals was approximately 0.91 times that of married individuals.

Education and economic levels

There was variation in the prevalence of LUTS/BPH among various education and economic levels. Prevalence was higher among individuals with more years of education and it was highest among individuals with college degrees or above ($P < 0.05$). The prevalence of LUTS/BPH was lower among individuals with a low GDP per capita.

Resident areas and regions

The prevalence of LUTS/BPH was higher among subjects residing in urban areas (rural: 8.38% [95% CI: 6.90, 10.15]; urban: 13.55% [95% CI: 10.95, 16.64]). The odds of LUTS/BPH in urban residents was 1.5 times that of rural residents. There was a significant difference in the prevalence of LUTS/BPH according to geographic location. The South-Central and South-West had the lowest prevalence of LUTS/BPH (9.76% and 9.53%, respectively), followed by the East (10.56%), North (12.18%) and North-East (12.24%) regions; prevalence was highest among respondents living in the North-West region (13.75%). Compared with the East region, the ORs for LUTS/BPH for the North, North-East, North-West, South-Central, South-West regions were 1.12 (95% CI: 0.75, 1.67), 1.03 (95% CI: 0.76, 1.39), 1.66 (95% CI: 1.12, 2.47), 0.90 (95% CI: 0.53, 1.55) and 1.01 (95% CI: 0.66, 1.53), respectively, after adjustment for age, marital status, rural/urban area, education and GDP per capita (Table 3). The prevalence of each region can be seen in Figure 1.

DISCUSSION

The CHARLS set up a high quality, nationally representative, publicly available micro-database, providing a wide range of information regarding the households of the elderly as well as individual information on the elderly respondents and their

spouses. Our research is based on data from the CHARLS. It was known from our study that LUTS/BPH was common among Chinese men age over 50 years. Age had great influence on prevalence of LUTS/BPH according to ours and other studies (15).

Rapid population aging in China is increasing the prevalence of LUTS/BPH among older people and so does the economic burdens associated with it. In our study, adjusted prevalence of LUTS/BPH among men aged beyond 50 years reached 10.66% (95% CI: 9.36, 12.12), which could influence their life quality and impose economic burdens on both individuals and society. The cost of intervention and treatment of BPH is comprised of direct costs (drugs, procedures, imaging, office visits), indirect costs (lost earnings) and intangible costs (pain and suffering) (16). It is likely that the costs for LUTS/BPH will continuously increase in the future. Therefore, a prevalence study on LUTS/BPH can help guide public health policy.

As definition of BPH varies, the prevalence varies (17). When responding positively to a question regarding diagnosis of a benign prostate illness, an individual means that some symptoms of LUTS occurred in him, and that he sought for medical care and was diagnosed with a benign prostate illness. Benign prostate illness primarily refers to prostatitis and BPH, which shared many overlapping symptoms. Prostatitis without BPH is a diagnosis of young men, however, inflammation in the prostate is also observed in elderly men presenting with BPH. Gandaglia et al. (18) suggested that histological prostatitis affected the progression of BPH because of the inflammatory process. Inflammation is a modifiable risk factor in BPH pathogenesis (15). Patients presenting with BPH may have a component of category IV, asymptomatic prostatitis (19). Thus, in our study, individuals over age 50 who responded positively to the question regarding diagnosis with a benign prostate illness were counted as having LUTS/BPH.

BPH increases with age, as has been confirmed by numerous studies. Loeb et al. (20) enrolled 278 men from the Baltimore Longitudinal Study of Aging and reported that

the median rate of volume change was 0.6 cc per year (range -9.9 to 62.1), corresponding to a median growth rate of 2.5% per year (range -29.2% to 176.4%). The study was based on autopsy. Although prostate volume is not related to LUTS severity directly, it is a risk factor. Roehrborn et al. (21) reported that larger prostate was associated with increased risks of urinary retention, increased future need for surgery and clinical progression of BPH. Another study, after follow-up for 16 years, reported significantly increased incidence and progression of LUTS in men with age (22). In our study, LUTS/BPH involved symptoms of LUTS and histological BPH. Individuals aged 60-69 years and ⩾70 years had a higher prevalence of LUTS/BPH, and the adjusted ORs were 1.5 (95% CI: 1.20, 1.87) and 2.09 (95% CI: 1.58, 2.78) respectively, compared with subjects age <60 years ($p < 0.05$).

Studies of sex steroid hormones and BPH revealed that androstanediols play a role in BPH development (23). Unmarried/separated/widowed individuals accounted 13.20% in all the respondent participants, having a lower adjusted prevalence of LUTS/BPH at 9.87% (95% CI: 6.56, 14.60). These people are usually thought have no or less sexual life compared with married men. Married men more often intended to visit doctor in case of their illness would have a negative impact on their spouse and family.

In several studies, socioeconomic status played an important role in progression of LUTS/BPH and might vary the results, particularly the prevalence and effects of LUTS/BPH (24). For example, some researchers found higher rates of BPH in upper income groups, but this may due to selection bias, because of higher utilization of medical care (25,26). Using data from the Korean Community Health Survey performed in 2011, Jo KJ et al. found that the severity of LUTS was associated with several socioeconomic factors, including education level, income level and living environment (27). Fowke et al. found that college education or higher levels was associated with a lower IPSS score (28). Education levels were obtained when people were young, and did not change with aging. Nevertheless, education influenced the

understanding of disease and the decision-making progress. In our study, we analyzed socioeconomic factors including GDP per capita, education levels and geographic region. Individuals with education of college degree or above had a high adjusted OR of LUTS/BPH at 2.67 (95% CI: 1.57, 4.54) (P<0.001), compared to individuals with no formal education. Individuals residing in urban areas were 1.5 times more likely to have the diagnosis than those in rural areas. We believe that there was inevitable selection bias, as residents living in urban areas may seek medical care more often than do those in rural areas. Some individuals lack the recognition of BPH and hospital visitation is often delayed.

We demonstrated an apparent geographic variation in the prevalence of LUTS/BPH in China. Residents in the South-West regions had a much lower prevalence of LUTS/BPH than did those living in the North-West regions of China. Individuals residing in the north regions, including North, North-East and North-West, had a relatively higher prevalence of LUTS/BPH than did those living in South-Central and South-West. Dietary differences may contribute to this discrepancy. Daily diet of individuals living in north regions contain much milk, dairy products and red meat, while individuals living in south regions consume more fruits and vegetables than do those in the north, which have both been confirmed to increase the risk of LUTS/BPH (29,30). Nevertheless, residents in East region did not show a high prevalence of LUTS/BPH. It was thought that socioeconomic development in the East region was, in general, higher than that of other regions, possibly contributing to the lower prevalence of LUTS/BPH. Furthermore, the genetic susceptibility of BPH was also a factor influencing the prevalence of LUTS/BPH in China. Several studies from China reported genetics associated with developing BPH (30), possibly one of the factors causing varying prevalence of LUTS/BPH in China.

Our research has several strengths. First, our data was based on the CHARLS, a national population survey. The interviewers were highly-trained and questionnaires were developed after a long and rigorous course. The participants were chosen via

strict multistage probability sampling procedures. Hence, data from the CHARLS can represent the national condition. Second, the prevalence of LUTS/BPH in China is difficult to estimate, not only because of the large population but also because of the diagnostic criteria. Using data from the CHARLS, we avoided both questions.

There are some limitations as well. First, the CHARLS did not collect weight and height, so we could not analyze the relationship of BMI or obesity and prevalence of LUTS/BPH. Second, testicular androgens are required in the prostate for the development of BPH. Third, as China is a large country, and we all adhere to the principles of diagnosis from the China Urology Association (CUA), the diagnosis of LUTS/BPH may be slightly different among regions. We cannot detect these differences, since the data of CHARLS provides an established diagnosis.

In this study, we looked at the prevalence of LUTS/BPH via CHARLS data. We found that the LUTS/BPH is highly prevalent in older, urban-living men. The prevalence varied according to marital status, socioeconomic status and geographic regions.

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Competing interest statement

None declared.

Author statement

Weiyu Zhang, Xiaopeng Zhang: Designed the study and drafted the article

Haibin Li, Feng Wu: Dealt with the statistics

Huanrui Wang, Meishan Zhao: Help with data sorting, literature retrieve, language polish and other chores

Hao Hu, Kexin Xu: Constructive revision and grasp of the overall situation

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Data sharing statement

No additional unpublished data are available.

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Table 1 The baseline of population

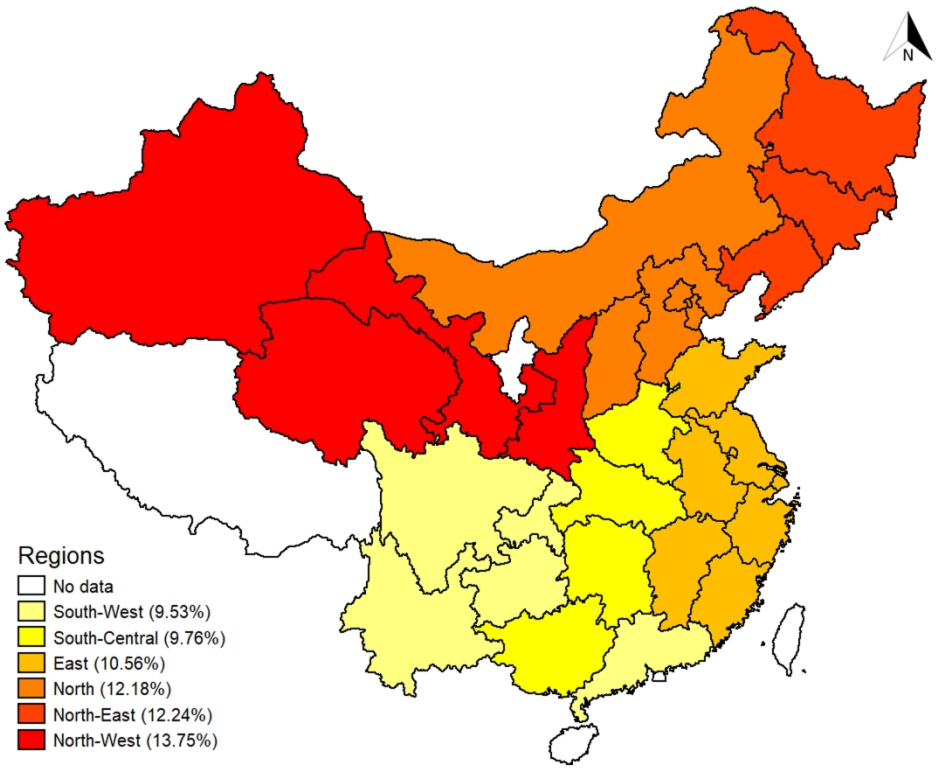
Characteristic	Men (n=5888)
Age, mean (SD)	62.78 (8.56)
Age group, No. (%)	
50-59	2356 (40.01)
60-69	2250 (38.21)
≥70	1282 (21.77)
Marital status, No. (%)	
Married	5111 (86.80)
Unmarried/Separated /Widowed	777 (13.20)
Education levels, No. (%)	
No formal education	1918 (32.84)
Elementary school	1573 (26.93)
Middle school	1426 (24.42)
High school	556 (9.52)
College degree or above	367 (6.28)
Geographic region, No. (%)	
Rural	3742 (63.55)
Urban	2146 (36.45)
GDP per capita, No. (%)	
Low	2114 (35.90)
Middle	1960 (33.29)
High	1814 (30.81)
Region, No. (%)	
East	2506 (42.56)
North	779 (13.23)
North-East	404 (6.86)
North-West	224 (3.80)
South-Central	974 (16.54)
South-West	1001 (17.00)

Table 2 The weighted prevalence

Characteristic	Case, No. (%)	Prevalence (%)	95% CI
Total	599 (10.17)	10.66	9.36-12.12
Age group, No. (%)			
50-59	182 (7.72)	8.39	7.01-9.98
60-69	236 (10.49)	10.61	8.67-12.91
≥70	181 (14.12)	14.67	11.80-18.09
Marital status, No. (%)			
Married	522 (10.21)	10.80	9.61-12.12
Unmarried/Separated /Widowed	77 (9.91)	9.87	6.56-14.60
Education levels, No. (%)			
No formal education	162 (8.45)	8.20	6.54-10.23
Elementary school	166 (10.55)	10.69	8.20-13.83
Middle school	130 (9.12)	9.17	6.71-12.40
High school	55 (9.89)	13.99	7.62-24.29
College degree or above	84 (22.89)	21.26	13.55-31.73
Geographic region, No. (%)			
Rural	328 (8.77)	8.38	6.90-10.15
Urban	271 (12.63)	13.55	10.95-16.64
GDP per capita, No. (%)			
Low	203 (9.60)	10.69	8.20-13.83
Middle	232 (11.84)	11.54	10.09-13.16
High	164 (9.04)	9.83	7.44-12.88
Region, No. (%)			
East	244 (9.74)	10.56	8.68-12.81
North	98 (12.58)	12.18	8.63-16.92
North-East	42 (10.40)	12.24	9.11-16.25
North-West	29 (12.95)	13.75	9.92-18.75
South-Central	91 (9.34)	9.76	6.47-14.45
South-West	95 (9.49)	9.53	6.24-14.31

Table 3 The adjusted odds ratio (OR) for the prevalence of LUTS/BPH

Characteristic	Crude OR (95 % CI)	Adjusted OR (95 % CI)	*P* value
Age group, No. (%)			
50-59	1.00 (reference)	1.00 (reference)	
60-69	1.29 (0.98-1.71)	1.50 (1.20-1.87)	0.001
≥70	1.87 (1.31-2.69)	2.09 (1.58-2.78)	0.000
Marital status, No. (%)			
Married	1.00 (reference)	1.00 (reference)	
Unmarried/Separated /Widowed	0.90(0.59-1.38)	0.91 (0.63-1.30)	0.597
Education levels, No. (%)			
No formal education	1.00 (reference)	1.00 (reference)	
Elementary school	1.34 (0.95-1.88)	1.36 (0.97-1.91)	0.074
Middle school	1.12 (0.79-1.61)	1.30 (0.93-1.82)	0.120
High school	1.82 (0.84-3.92)	2.27 (1.03-4.99)	0.043
College degree or above	3.02 (1.67-5.43)	2.67 (1.57-4.54)	0.000
Geographic region, No. (%)			
Rural	1.00 (reference)	1.00 (reference)	
Urban	1.71 (1.24-2.36)	1.50 (1.71-1.92)	0.002
GDP per capita, No. (%)			
Low	1.00 (reference)	1.00 (reference)	
Middle	1.08(0.77-1.53)	1.23 (0.94-1.62)	0.130
High	0.91(0.58-1.42)	0.99 (0.69-1.42)	0.958
Region, No. (%)			
East	1.00 (reference)	1.00 (reference)	
North	1.17 (0.74-1.84)	1.12 (0.75-1.67)	0.578
North-East	1.18 (0.77-1.79)	1.03 (0.76-1.39)	0.844
North-West	1.35 (0.86-2.11)	1.66 (1.12-2.47)	0.012
South-Central	0.91 (0.55-1.51)	0.90 (0.53-1.55)	0.696
South-West	0.89 (0.53-1.50)	1.01 (0.66-1.53)	0.970



The prevalence of LUTS/BPH in each regions

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The prevalence of lower urinary tract symptoms suggestive of benign prostatic hyperplasia (LUTS/BPH) in China: results from the China Health and Retirement Longitudinal Study

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The prevalence of lower urinary tract symptoms suggestive of benign prostatic hyperplasia (LUTS/BPH) in China: results from the China Health and Retirement Longitudinal Study

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ABSTRACT

Objective. Rapid population aging in China is increasing the prevalence of lower urinary tract symptoms suggestive of benign prostatic hyperplasia (LUTS/BPH) among older people. The associated economic burdens are increasing as well. Relevant data from China is currently insufficient.

Design. Secondary analysis of a cohort sample.

Setting. A nationally representative cross-sectional survey—the China Health and Retirement Longitudinal Study (CHARLS) was conducted in 2011 in mainland China.

Participants. Individuals in the community selected from the CHARLS by multistage probability sampling. A total of 5888 participants aged 50 years and above were included.

Outcome measures. Self-reported morbid state was derived from a structured questionnaire. The weighted-prevalence of LUTS/BPH was estimated and stratified by age group, marital status, education levels, economic levels, residential areas and geographic regions. Multivariable weighted logistic regression was used to examine the association of socioeconomic status with the odds of BPH.

Results. The weighted overall prevalence of LUTS/BPH was 10.66% (95% confidence interval [CI], 9.36-12.12). Among individuals age over 70 years, the prevalence was 14.67% (95% CI, 11.80-18.09), and it increased with aging (P<0.05). The prevalence of LUTS/BPH among subjects residing the urban areas was higher [13.55% (95% CI, 10.95-16.64)] than those living in rural areas [8.38% (95% CI, 6.90-10.15)]. The prevalence of LUTS/BPH was lowest in the South-Central and South-West and highest the North-West region.

Conclusions. We found an increasing trend of prevalence of LUTS/BPH with aging. It varied according to marital status, socioeconomic status and geographic region.

Keywords LUTS/BPH; epidemiology; China

Strengths and limitations

- Our data is based on the CHARLS, a strict national population survey.
- Prevalence of LUTS/BPH in China is difficult to estimate, not only because of the large population but also because of the diagnostic criteria.
- The CHARLS did not collect weights and heights, so we could not analyze the relationship of BMI and obesity with prevalence of LUTS/BPH.

Benign prostatic hyperplasia (BPH) is a common disease of men, representing a substantial disease burden. BPH is characterized by a proliferation of both stromal and epithelial cells of the prostate in the transitional zone surrounding the urethra (1). Approximately 50% of men >50 years of age have pathological evidence of BPH, increasing to >80% as men reach their eighth decade of life and older (2). When men reach 80 years, this number increases to 83% (3). As the world population aged, the incidence and prevalence of BPH have rapidly increased (4). Lower urinary tract symptoms (LUTS) have been specified by the standardization subcommittee of the International Continence Society (ICS) in February 2002: "LUTS are the subjective indicators of a disease or change in conditions as perceived by the patients, carer or partners and may lead him/her to seek help from health care professionals. Symptoms may either be volunteered or described during the patient interview. They are usually qualitative" (5). However, in 2006, Chapple and Roehrborn emphasized that the presence of LUTS does not need to be associated with prostatic pathology only (6). Therefore, LUTS/BPH in our study referred to symptomatic BPH. Although it is not life-threatening, LUTS/BPH is associated with serious morbidities and decreases quality of life (7,8). In America, LUTS/BPH affects more than 20% of American men aged 30 to 79 years, or roughly 15 million men (9,10). The prevalence of BPH in China is currently determined from autopsy data and a few studies based on the general population that cannot accurately reflect the current status of the disease (11). No study has been conducted for LUTS/BPH in China. Therefore, there is a paucity of data regarding prevalence of LUTS/BPH and its potential risk factors among the elderly in China.

China has a population of 1.3 billion, 25.3% aged 50 years or older and 13.26% aged more than 60 years (12). The aging of the general population means that elderly people now account for a much greater proportion of patients with BPH. Many modifiable risk factors play roles in pathogenesis of BPH, including sex steroid hormones, the metabolic syndrome cardiovascular disease, obesity, diabetes, diet, physical activity and inflammation. These risk factors cause a large variation of

prevalence of LUTS/BPH in various regions of China. Epidemiological studies comparing prevalence of LUTS/BPH according to age, socioeconomic status and geographic region by the same research method will provide reliable estimates on the understanding of potential risk factors of LUTS/BPH and help design health care plans.

Using data collected from the China Health and Retirement Longitudinal Study (CHARLS), a national random sample of the Chinese population (13), we estimated the prevalence of LUTS/BPH among residents aged 50 years or older in China according to age, marital status, education levels, geographic region and socioeconomic status.

The project team filed an ethics review application to Ethical Review Committee (IRB) at Peking University in June 2008 and obtained approval.

METHODS

The CHARLS is a survey of the elderly in China, based on a sample of households with members middle-aged and elderly and their spouses. Individuals aged 50 years and above were included in this study. Data on social-economic and health status were collected using standardized questionnaire (13). The baseline survey was conducted in 2011–2012 covering 450 villages/urban communities in 28 provinces. Eligible individuals were selected through four-stage, stratified cluster sampling. Probabilities proportional to size (PPS) sampling were used in the determination of sample size. Detailed descriptions were provided in a previous publication (14).

Definitions of LUTS/BPH

BPH is a term reserved for the typical histological pattern that defines the disease. However, many men with histological BPH never seek medical care, nor do they require treatment for it. The condition proceeds differently when it is associated with LUTS. Individuals with histologic BPH visit a doctor only when LUTS occurs. Residents who participated in CHARLS were asked whether they have ever been

diagnosed with a prostate illness (excluding prostatic cancer). We defined him as a subject with LUTS/BPH if he responded positively to this question.

Data collection and grouping

The households were selected randomly and age-eligibly. All participants had a face-to-face household-interview using a structured questionnaire. Information collected during the household-interview included demographic factors, socioeconomic status and medical history. The statistical analysis results will not disseminate to study participants in short time.

Subjects were grouped into 3 strata according to age: 50-59, 60-69 and ⩾70 years old. The marital status was divided into married and unmarried/separated/widowed. Education level was divided into 5 categories: no formal education, elementary school, middle school, high school and college degree or above. Geographic region was divided into rural and urban. The economic level were defined according to the tertile of GDP. We categorized their living localities into six regions, i.e., East (7 provinces: Shandong, Jiangsu, Shanghai, Zhejiang, Fujian, Anhui, Jiangxi), North (2 cities: Beijing and Tianjin and 3 provinces: Hebei, Shanxi and Inner Mongolia), North-East (3 provinces: Liaoning, Jilin and Heilongjiang), North-West (4 provinces: Shaanxi, Gansu, Qinghai and Xinjiang), South-Central (5 provinces: Henan, Hubei, Hunan, Guangdong and Guangxi) and South-West (1 city: Chongqing and 3 provinces: Sichuan, Guizhou and Yunnan). Individuals living in Hainan, Ningxia, Taiwan and Tibet were not selected in this survey.

Patient and Public Involvement

Patients and/or public where not involved in the design or conduct of this study.

Statistical analyses

We used Stata to calculate the overall and age-specific prevalence of LUTS/BPH according to strata for each factor. The svy: logistic procedure in Stata version 14.2

was used to examine the association between each risk factor and the prevalence of BPH, adjusting for other potential confounders including gender, age, area, education, GDP per capita, and region. Both procedures considered the complex survey design and the non-response rate for the CHARLS survey when estimating the prevalence, prevalence odds ratio (OR), and corresponding standard errors.

RESULTS

A total of 5,888 participants were involved in our study and the characteristics of the baseline population are given in Table 1. Five hundred and ninety-nine responded positively. Mean age was 62.78 (standard deviation: 8.56). Most of the participants were married. About a quarter of the participants did not receive formal education and half of the rest received elementary or middle school education. The majority of the respondent participants lived in rural areas. About one third of respondents were classified in three levels of GDP per capita.

The weighted overall prevalence of LUTS/BPH was 10.66% (95% confidence interval [CI]: 9.36, 12.12). The weighted results are listed in Table 2.

Age

Aging men were more likely to be diagnosed with LUTS/BPH, and the weighted prevalence of LUTS/BPH increased with age. Compared with subjects age <60 years, the adjusted odds ratios (OR) for the prevalence of LUTS/BPH were 1.50 (95% CI: 1.20, 1.87) for those age 60-69 years and 2.09 (95% CI: 1.58, 2.78) for those aged $\geqslant$ 70 years (Table 3).

Marital status

The prevalence of LUTS/BPH was slightly higher among married individuals, at 10.80% (95% CI: 9.61, 12.12) while the prevalence among unmarried/separated/widowed individuals was 9.87% (95% CI: 6.56, 14.60). The odds of LUTS/BPH in

unmarried/separated/widowed individuals was approximately 0.91 times that of married individuals.

Education and economic levels

There was variation in the prevalence of LUTS/BPH among various education and economic levels. Prevalence was higher among individuals with more years of education and it was highest among individuals with college degrees or above ($P < 0.05$). The prevalence of LUTS/BPH was lower among individuals with a low GDP per capita.

Resident areas and regions

The prevalence of LUTS/BPH was higher among subjects residing in urban areas (rural: 8.38% [95% CI: 6.90, 10.15]; urban: 13.55% [95% CI: 10.95, 16.64]). The odds of LUTS/BPH in urban residents was 1.5 times that of rural residents. There was a significant difference in the prevalence of LUTS/BPH according to geographic location. The South-Central and South-West had the lowest prevalence of LUTS/BPH (9.76% and 9.53%, respectively), followed by the East (10.56%), North (12.18%) and North-East (12.24%) regions; prevalence was highest among respondents living in the North-West region (13.75%). Compared with the East region, the ORs for LUTS/BPH for the North, North-East, North-West, South-Central, South-West regions were 1.12 (95% CI: 0.75, 1.67), 1.03 (95% CI: 0.76, 1.39), 1.66 (95% CI: 1.12, 2.47), 0.90 (95% CI: 0.53, 1.55) and 1.01 (95% CI: 0.66, 1.53), respectively, after adjustment for age, marital status, rural/urban area, education and GDP per capita (Table 3). The prevalence of each region can be seen in Figure 1.

DISCUSSION

The CHARLS set up a high quality, nationally representative, publicly available micro-database, providing a wide range of information regarding the households of the elderly as well as individual information on the elderly respondents and their

spouses. Our research is based on data from the CHARLS. It was known from our study that LUTS/BPH was common among Chinese men age over 50 years. Age had great influence on prevalence of LUTS/BPH according to ours and other studies (15).

Rapid population aging in China is increasing the prevalence of LUTS/BPH among older people and so does the economic burdens associated with it. In our study, adjusted prevalence of LUTS/BPH among men aged beyond 50 years reached 10.66% (95% CI: 9.36, 12.12), which could influence their life quality and impose economic burdens on both individuals and society. The cost of intervention and treatment of BPH is comprised of direct costs (drugs, procedures, imaging, office visits), indirect costs (lost earnings) and intangible costs (pain and suffering) (16). It is likely that the costs for LUTS/BPH will continuously increase in the future. Therefore, a prevalence study on LUTS/BPH can help guide public health policy.

As definition of BPH varies, the prevalence varies (17). When responding positively to a question regarding diagnosis of a benign prostate illness, an individual means that some symptoms of LUTS occurred in him, and that he sought for medical care and was diagnosed with a benign prostate illness. Benign prostate illness primarily refers to prostatitis and BPH, which shared many overlapping symptoms. Prostatitis without BPH is a diagnosis of young men, however, inflammation in the prostate is also observed in elderly men presenting with BPH. Gandaglia et al. (18) suggested that histological prostatitis affected the progression of BPH because of the inflammatory process. Inflammation is a modifiable risk factor in BPH pathogenesis (15). Patients presenting with BPH may have a component of category IV, asymptomatic prostatitis (19). Thus, in our study, individuals over age 50 who responded positively to the question regarding diagnosis with a benign prostate illness were counted as having LUTS/BPH.

BPH increases with age, as has been confirmed by numerous studies. Loeb et al. (20) enrolled 278 men from the Baltimore Longitudinal Study of Aging and reported that

the median rate of volume change was 0.6 cc per year (range -9.9 to 62.1), corresponding to a median growth rate of 2.5% per year (range -29.2% to 176.4%). The study was based on autopsy. Although prostate volume is not related to LUTS severity directly, it is a risk factor. Roehrborn et al. (21) reported that larger prostate was associated with increased risks of urinary retention, increased future need for surgery and clinical progression of BPH. Another study, after follow-up for 16 years, reported significantly increased incidence and progression of LUTS in men with age (22). In our study, LUTS/BPH involved symptoms of LUTS and histological BPH. Individuals aged 60-69 years and ⩾70 years had a higher prevalence of LUTS/BPH, and the adjusted ORs were 1.5 (95% CI: 1.20, 1.87) and 2.09 (95% CI: 1.58, 2.78) respectively, compared with subjects age <60 years ($p < 0.05$).

Studies of sex steroid hormones and BPH revealed that androstanediols play a role in BPH development (23). Unmarried/separated/widowed individuals accounted 13.20% in all the respondent participants, having a lower adjusted prevalence of LUTS/BPH at 9.87% (95% CI: 6.56, 14.60). These people are usually thought have no or less sexual life compared with married men. Married men more often intended to visit doctor in case of their illness would have a negative impact on their spouse and family.

In several studies, socioeconomic status played an important role in progression of LUTS/BPH and might vary the results, particularly the prevalence and effects of LUTS/BPH (24). For example, some researchers found higher rates of BPH in upper income groups, but this may due to selection bias, because of higher utilization of medical care (25,26). Using data from the Korean Community Health Survey performed in 2011, Jo KJ et al. found that the severity of LUTS was associated with several socioeconomic factors, including education level, income level and living environment (27). Fowke et al. found that college education or higher levels was associated with a lower IPSS score (28). Education levels were obtained when people were young, and did not change with aging. Nevertheless, education influenced the

understanding of disease and the decision-making progress. In our study, we analyzed socioeconomic factors including GDP per capita, education levels and geographic region. Individuals with education of college degree or above had a high adjusted OR of LUTS/BPH at 2.67 (95% CI: 1.57, 4.54) (P<0.001), compared to individuals with no formal education. Individuals residing in urban areas were 1.5 times more likely to have the diagnosis than those in rural areas. We believe that there was inevitable selection bias, as residents living in urban areas may seek medical care more often than do those in rural areas. Some individuals lack the recognition of BPH and hospital visitation is often delayed.

We demonstrated an apparent geographic variation in the prevalence of LUTS/BPH in China. Residents in the South-West regions had a much lower prevalence of LUTS/BPH than did those living in the North-West regions of China. Individuals residing in the north regions, including North, North-East and North-West, had a relatively higher prevalence of LUTS/BPH than did those living in South-Central and South-West. Dietary differences may contribute to this discrepancy. Daily diet of individuals living in north regions contain much milk, dairy products and red meat, while individuals living in south regions consume more fruits and vegetables than do those in the north, which have both been confirmed to increase the risk of LUTS/BPH (29,30). Nevertheless, residents in East region did not show a high prevalence of LUTS/BPH. It was thought that socioeconomic development in the East region was, in general, higher than that of other regions, possibly contributing to the lower prevalence of LUTS/BPH. Furthermore, the genetic susceptibility of BPH was also a factor influencing the prevalence of LUTS/BPH in China. Several studies from China reported genetics associated with developing BPH (30), possibly one of the factors causing varying prevalence of LUTS/BPH in China.

Our research has several strengths. First, our data was based on the CHARLS, a national population survey. The interviewers were highly-trained and questionnaires were developed after a long and rigorous course. The participants were chosen via

strict multistage probability sampling procedures. Hence, data from the CHARLS can represent the national condition. Second, the prevalence of LUTS/BPH in China is difficult to estimate, not only because of the large population but also because of the diagnostic criteria. Using data from the CHARLS, we avoided both questions.

There are some limitations as well. First, the CHARLS did not collect weight and height, so we could not analyze the relationship of BMI or obesity and prevalence of LUTS/BPH. Second, testicular androgens are required in the prostate for the development of BPH. Third, as China is a large country, and we all adhere to the principles of diagnosis from the China Urology Association (CUA), the diagnosis of LUTS/BPH may be slightly different among regions. We cannot detect these differences, since the data of CHARLS provides an established diagnosis.

In this study, we looked at the prevalence of LUTS/BPH via CHARLS data. We found that the LUTS/BPH is highly prevalent in older, urban-living men. The prevalence varied according to marital status, socioeconomic status and geographic regions.

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Competing interest statement

None declared.

Author statement

Weiyu Zhang, Xiaopeng Zhang: Designed the study and drafted the article

Haibin Li, Feng Wu: Dealt with the statistics

Huanrui Wang, Meishan Zhao: Help with data sorting, literature retrieve, language polish and other chores

Hao Hu, Kexin Xu: Constructive revision and grasp of the overall situation

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Data sharing statement

CHARLS is based on the Health and Retirement Study (HRS) and related aging surveys such as the English Longitudinal Study of Aging (ELSA) and the Survey of Health, Aging and Retirement in Europe (SHARE). All of the data was obtained from CHARLS database (http://charls.pku.edu.cn/zh-CN) with open access.

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Table 1 Baseline population characteristics

Characteristic	Men (n=5888)
Age, mean (SD)	62.78 (8.56)
Age group, No. (%)	
50-59	2356 (40.01)
60-69	2250 (38.21)
⩾70	1282 (21.77)
Marital status, No. (%)	
Married	5111 (86.80)
Unmarried/Separated /Widowed	777 (13.20)
Education levels, No. (%)*	
No formal education	1918 (32.84)
Elementary school	1573 (26.93)
Middle school	1426 (24.42)
High school	556 (9.52)
College degree or above	367 (6.28)
Geographic region, No. (%)	
Rural	3742 (63.55)
Urban	2146 (36.45)
GDP per capita, No. (%)	
Low	2114 (35.90)
Middle	1960 (33.29)
High	1814 (30.81)
Region, No. (%)	
East	2506 (42.56)
North	779 (13.23)
North-East	404 (6.86)
North-West	224 (3.80)
South-Central	974 (16.54)
South-West	1001 (17.00)

*, Education levels values of 48 cases was missed.

Table 2 Weighted prevalence

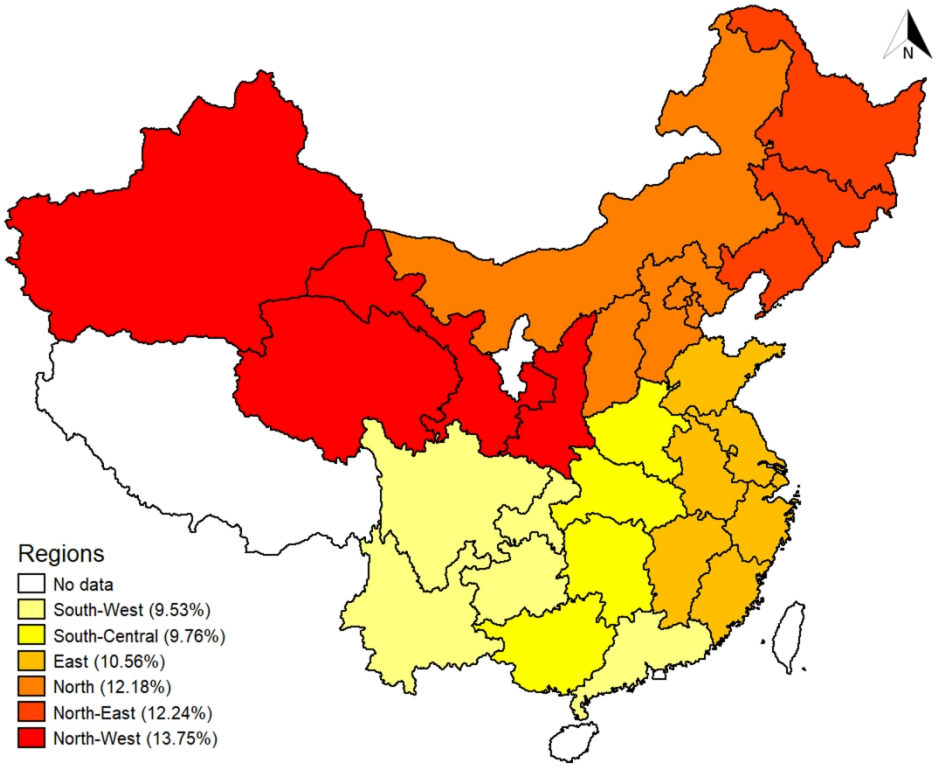
Characteristic	Case, No. (%)	Prevalence (%)	95% CI
Total	599 (10.17)	10.66	9.36-12.12
Age group, No. (%)			
50-59	182 (7.72)	8.39	7.01-9.98
60-69	236 (10.49)	10.61	8.67-12.91
⩾70	181 (14.12)	14.67	11.80-18.09
Marital status, No. (%)			
Married	522 (10.21)	10.80	9.61-12.12
Unmarried/Separated /Widowed	77 (9.91)	9.87	6.56-14.60
Education levels, No. (%)*			
No formal education	162 (8.45)	8.20	6.54-10.23
Elementary school	166 (10.55)	10.69	8.20-13.83
Middle school	130 (9.12)	9.17	6.71-12.40
High school	55 (9.89)	13.99	7.62-24.29
College degree or above	84 (22.89)	21.26	13.55-31.73
Geographic region, No. (%)			
Rural	328 (8.77)	8.38	6.90-10.15
Urban	271 (12.63)	13.55	10.95-16.64
GDP per capita, No. (%)			
Low	203 (9.60)	10.69	8.20-13.83
Middle	232 (11.84)	11.54	10.09-13.16
High	164 (9.04)	9.83	7.44-12.88
Region, No. (%)			
East	244 (9.74)	10.56	8.68-12.81
North	98 (12.58)	12.18	8.63-16.92
North-East	42 (10.40)	12.24	9.11-16.25
North-West	29 (12.95)	13.75	9.92-18.75
South-Central	91 (9.34)	9.76	6.47-14.45
South-West	95 (9.49)	9.53	6.24-14.31

*, Education levels values of 48 cases was missed.

Table 3 The adjusted odds ratio (OR) for the prevalence of LUTS/BPH

Characteristic	Crude OR (95 % CI)	Adjusted OR (95 % CI)	*P* value
Age group, No. (%)			<0.001
50-59	1.00 (reference)	1.00 (reference)	
60-69	1.29 (0.98-1.71)	1.50 (1.20-1.87)	0.001
⩾70	1.87 (1.31-2.69)	2.09 (1.58-2.78)	<0.001
Marital status, No. (%)			
Married	1.00 (reference)	1.00 (reference)	
Unmarried/Separated /Widowed	0.90(0.59-1.38)	0.91 (0.63-1.30)	0.597
Education levels, No. (%)			0.001
No formal education	1.00 (reference)	1.00 (reference)	
Elementary school	1.34 (0.95-1.88)	1.36 (0.97-1.91)	0.074
Middle school	1.12 (0.79-1.61)	1.30 (0.93-1.82)	0.120
High school	1.82 (0.84-3.92)	2.27 (1.03-4.99)	0.043
College degree or above	3.02 (1.67-5.43)	2.67 (1.57-4.54)	0.000
Geographic region, No. (%)			
Rural	1.00 (reference)	1.00 (reference)	
Urban	1.71 (1.24-2.36)	1.50 (1.71-1.92)	0.002
GDP per capita, No. (%)			0.156
Low	1.00 (reference)	1.00 (reference)	
Middle	1.08(0.77-1.53)	1.23 (0.94-1.62)	0.130
High	0.91(0.58-1.42)	0.99 (0.69-1.42)	0.958
Region, No. (%)			0.200
East	1.00 (reference)	1.00 (reference)	
North	1.17 (0.74-1.84)	1.12 (0.75-1.67)	0.578
North-East	1.18 (0.77-1.79)	1.03 (0.76-1.39)	0.844
North-West	1.35 (0.86-2.11)	1.66 (1.12-2.47)	0.012
South-Central	0.91 (0.55-1.51)	0.90 (0.53-1.55)	0.696
South-West	0.89 (0.53-1.50)	1.01 (0.66-1.53)	0.970

Figure 1 The prevalence of each region



The prevalence of LUTS/BPH in each regions

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract **[2]**
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found **[3]**
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported **[5]**
Objectives	3	State specific objectives, including any prespecified hypotheses **[5]**
Methods		
Study design	4	Present key elements of study design early in the paper **[6]**
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection **[6-7]**
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants **[7]**
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group **[7]**
Bias	9	Describe any efforts to address potential sources of bias **[N/A]**
Study size	10	Explain how the study size was arrived at **[7]**
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why **[7]**
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding **[7-8]**
		(*b*) Describe any methods used to examine subgroups and interactions **[N/A]**
		(*c*) Explain how missing data were addressed **[N/A]**
		(*d*) If applicable, describe analytical methods taking account of sampling strategy **[N/A]**
		(*e*) Describe any sensitivity analyses **[N/A]**
Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed **[8]**
		(b) Give reasons for non-participation at each stage **[N/A]**
		(c) Consider use of a flow diagram **[N/A]**
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders **[8-9]**
		(b) Indicate number of participants with missing data for each variable of interest **[N/A]**
Outcome data	15*	Report numbers of outcome events or summary measures **[8-9]**
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included **[18]**

		(*b*) Report category boundaries when continuous variables were categorized **[N/A]**
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period **[N/A]**
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses **[N/A]**
Discussion		
Key results	18	Summarise key results with reference to study objectives **[13]**
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias **[13]**
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence **[9-12]**
Generalisability	21	Discuss the generalisability (external validity) of the study results **[N/A]**
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based **[N/A]**

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.