ELSEVIER

Urinary Tract Infection: Self-Reported Incidence and Associated Costs

BETSY FOXMAN, PHD, ROBIN BARLOW, PHD, HANNAH D'ARCY, MS, BRENDA GILLESPIE, PHD, AND JACK D. SOBEL, MD

PURPOSE: To estimate the annual incidence, cumulative probability of presumed urinary tract infection (UTI) by age, and the social costs.
METHODS: Analysis of a random digit dialing survey of 2000 women in the United States.
RESULTS: 10.8 percent (95% CI: 9.4, 12.1%) of women aged 18 and older reported at least one presumed UTI during the past 12 months, with the majority of the cases occurring among women with a history of two or more UTI episodes in their life. We estimate that by age 24, one-third of women will have at least one physician-diagnosed UTI that was treated with prescription medication. Overall, an estimated 11.3 million women in the United States had at least one presumed UTI treated with antibiotics in 1995. We estimate the annual cost of UTI cases with prescriptions to be $1.6 billion in 1995. If the costs occurring after 1995 are discounted at 5% annually, the total cost over 20 years has a present value of $25.5 billion.
CONCLUSION: If a vaccine were developed that would prevent either initial or recurrent UTI the net benefits to society would be substantial, even at a developmental cost of one billion dollars.
Ann Epidemiol 2000;10:509–515.

KEY WORDS: Urinary Tract Infection, Incidence, Costs, Women, Survey, Risk.

INTRODUCTION

Urinary tract infection (UTI) is one of the most common problems seen by primary care physicians; there are approximately 7.3 million office visits by women for urinary tract infections or cystitis annually (1). Half of the women participating in the Rand Health Insurance Experiment and 15% of the men reported at least one UTI by age 35 (2). The incidence of symptomatic infection among the general population is unknown, although in a prospective cohort study of healthy, sexually active women aged 18 to 40 with a history of no more than one UTI in the past 12 months, the incidence was 0.7 per person-year among university women and 0.5 per person-year among women at a health maintenance organization (3).

We estimated the annual incidence of UTI and the cumulative probability of at least one physician-diagnosed UTI by age from a random digit dialing survey of 2000 women representative of the United States population. We used these results along with socio-demographic information to estimate the total direct and indirect costs of UTI.

METHODS

Random Digit Dialing Survey

As described previously, we obtained a random digit dialing sample of 29,754 United States non-business listed and unlisted phone numbers from Survey Sampling, Inc. of Westport, CT (4). The woman aged 18 or older with the most recent birthday was interviewed in all households reached where there was an eligible woman. The cooperation rate (the ratio of the number of completed interviews to the total number of completed, partially completed interviews and refusals, excluding known ineligibles) was 54.0%. The survey ascertained each woman's lifetime number of UTIs, date of her first and last UTI, and her age, education, employment status, marital status, and if she had any children.

UTI Definition

A woman was considered to have had a UTI if she answered yes to the question "Has a healthcare professional such as a physician or nurse practitioner ever told you that you had a urinary tract infection? For example, a bladder infection, cystitis, kidney infection or pyelonephritis?" and she stated that her last UTI was treated with a prescription medication. To highlight that errors in patient report and physician

From the Department of Epidemiology (B.F., R.B.), University of Michigan School of Public Health, Ann Arbor, MI; Center for Statistical Consultation and Research (H.d'A., B.G.), University of Michigan, Ann Arbor, MI; and Division of Infectious Diseases (J.D.S.), Wayne State University, Detroit, MI.
Address correspondence to: Dr. Foxman, Department of Epidemiology, 109 Observatory Street, Ann Arbor, MI 48109-2029.

655 Avenue of the Americas, New York, NY 10010
1047-2797/00/$–see front matter
PII S1047-2797(00)00072-7

diagnosis may lead to an over-estimate of UTI incidence we use the terminology "self-reported presumed UTI."

Cost Estimates

We estimated the total social cost of UTI by estimating direct medical and non-medical expenses, and indirect costs based on information provided partly by our random digit dialing survey and partly from other sources. The assumptions employed in the calculations are shown in Table 1.

The direct costs of a disease are those incurred in treating it, such as drug expenses and payments to health care facilities. In addition we included expenses for travel to and from the facility, expenses for child care during the visit to the facility, and the value of the time spent by the patient in making the visit.

We defined the indirect costs of UTI as the loss of output due to disability, over and above the loss due to the time spent visiting a physician. Estimation of the disability losses requires information about the duration of the different degrees of disability associated with each episode (the durations being shorter with effective medication), and about the output lost per day of full disability. In our estimation of lost output, we have included not only output in paid employment but also output from unpaid activities like housekeeping. We make the conventional assumption that for an employed person, the output lost per day of full disability is approximated in market conditions by that person's daily wage. Our telephone survey obtained information about employment but not wages. However, we estimated each respondent's wage based on a regression model developed using data from the Panel Study of Income Dynamics (9). This model predicted wage as a function of four variables included in our telephone survey: age, education, marital status, and number of children.

As defined here, the total social cost measures the economic burden on society. We did not measure where the financial burden lies, in the sense of how the total cost is distributed between patients, insurance companies, employers, and others. The cost estimates cover only those UTI cases where a prescription was issued. Omitted are expenses also incurred in these cases for nonprescription drugs, plus all direct and indirect costs of cases where no prescription was issued, plus psychic costs of pain and anxiety. Also omitted are costs of adverse reactions to antibiotic therapy, or of misdiagnosis, for example, treating a chlamydial infection as if it were a UTI.

Data Analysis

Twelve-month incidences were calculated using March 1995 through February 1996 as the incidence period. We used the most recent 12 months to avoid problems of recall bias. A case was considered incident if either the first or most recent UTI was in the incidence period. As the survey did not ask the number of UTI during the past 12 months, we have included at most one UTI per woman in our estimates of annual incidence and costs. Therefore our estimates of presumed UTI are conservative, possibly by as much as 50% (11). When the date of last UTI or use of medication was unknown ($n = 189$) we conservatively assumed that the woman did not have a UTI during the past 12 months. To estimate the annual number of UTI nationally, we multiplied the age-specific incidence rate estimates by the 1995 age distribution of women in the United States (12).

We calculated the cumulative probability of first UTI by age using Kaplan-Meier estimates, and Hall-Wellner 95% confidence bands around the estimates (13). Women reporting no lifetime UTI were considered to be censored at their current age. Information on year of first UTI was available in 788 of 959 cases. All analyses were done using SAS (14); exact confidence intervals were calculated with EpiInfo (15).

RESULTS

Incidence

Overall, 10.8% (95% CI: 9.4, 12.2%) of women aged 18 and older reported at least one presumed UTI during the past 12 months (Figure 1), with the majority of the cases in each age group occurring among women with a cumulative total of two or more UTI episodes in their life. The burden of disease is primarily on younger women: 17.5% (95% CI: 12.0, 22.9%) of women aged 18 to 24 reported a presumed UTI in the past 12 months. However, the frequency remains substantial, with the lowest incidence—6.5% (95% CI: 2.4, 10.6%)—occurring among women aged 55 to 59. These incidences translate to 11.3 million women with a presumed UTI in the United States in 1995. This estimate includes only women who had at least one physician-diagnosed UTI, and reported that their presumed UTI that occurred during the past 12 months was treated with a prescription medication. After adjustment for age, the incidence of presumed UTI did not vary by education, employment status, or race. When examined by marital status, divorced women had the highest incidence of presumed UTI in the past 12 months (21.2%) and widowed women the lowest (6.3%) ($p < 0.001$). After adjustment for age, divorced women still had a significantly higher incidence of presumed UTI.

Cumulative Probability of UTI by Age

UTI is extremely common: by age 26, one-third of the women in our sample had had a least one physician-diagnosed presumed UTI (Figure 2). Lifetime risk of UTI in our sample was 60.4% (95% Confidence Band: 55.1, 65.8).

Costs

The annual social cost in 1995 of presumed UTI cases with prescriptions was $1.6 billion (Table 2). This includes $474

TABLE 1. Assumptions made for estimation of cost of urinary tract infection, 1995

Parameter definition		Assumed value	Reference
Health data			
CAS	Annual number of UTI cases with prescription (millions)	11.3	[a]
	Sick days per UTI case if prescription ineffective		
SBI	Bed days	0.6	[b]
SRI	Other days of restricted activity	1.2	[b]
SSI	Other days with symptoms	2.7	[b]
	Sick days per UTI case if prescription effective		
SBE	Bed days	0.4	5
SRE	Other days of restricted activity	0.8	5
SSE	Other days with symptoms	1.8	5
	Degree of disability during sickness (proportion):		
DB	Bed days	1	[c]
DR	Other days of restricted activity	0.5	[c]
DR	Other days with symptoms	0.25	[c]
PD	Proportion of UTI cases with prescription who visited doctor	0.68	[a,d]
PCD	Proportion of UTI-case prescription consumed if visited doctor	1	[c]
PCN	Proportion of UTI-case prescription consumed if did not visit doctor	0.75	[c]
PNR	Proportion of consumed UTI-case prescriptions not encountering drug resistance	0.82	6
PE	Proportion of UTI cases with prescription where prescription was effective	0.75	PNR[PD*PCD+(1-PD)*PCN]
Cost data			
$DV	Clinic charges per doctor visit	$50.00	7
$TC	Travel and child-care expenses per doctor visit	$10.00	[c]
HDV	Patient time spent per doctor visit	2 hours	[c]
$P	Cost per prescription	$7.86	[e]
HP	Paid work hours per day	3.12	[a]
HU	Unpaid work hours per day	3.00	8
$PW	Output per hour of paid work	$12.13	9
$UW	Output per hour of unpaid work	$7.00	[c]
$L	Output lost per day of full disability	$58.82	HP*$PW+HU*$UW

[a] Random digit dialing survey.
[b] Assumed to be 50% higher than when prescription effective.
[c] Assumption based on authors' judgment.
[d] Cases not visiting a doctor get their prescriptions by telephone or use antibiotics previously obtained. These cases are assumed to be those with eight or more lifetime UTI episodes. This assumption implies 7.4 million doctor visits for UTI cases, a figure consistent with the findings of the 1995 National Ambulatory Medical Care Survey (1).
[e] Mean cost for the two most common drugs: bactrim/septra/trimethoprim-sulfa and macrodantin/nitrofurantoin (10).

million in medical expenses, $185 million in non-medical expenses and $936 million in indirect costs. Of the total annual social cost, 59% were indirect costs. About one-third of the indirect costs consisted of losses of output in unpaid work such as housekeeping. (The losses of unpaid output per day of full disability are calculated from Table 1 as HU*$UW.)

Several of the assumptions of the cost analysis might be questioned, therefore some sensitivity analysis is in order. The information used for the cost estimates is presented in Tables 1 and 2 in such a way that the consequences of alternative assumptions can be readily calculated. We assumed, for example, that the average cost of a prescription was $7.86. The estimated total annual cost is not very sensitive to drug price: at $4 per prescription the total cost is $1.551 billion; at $20 it is $1.732 billion.

Another source of uncertainty in our cost estimates is sampling error. A key parameter is the percentage of women with a presumed UTI in 1995. As noted above, the 95% confidence interval for this parameter extends from 9.4% to 12.2%. If the lower end of this range is preferred, the total cost of the disease in 1995 is $1.388 billion; using the upper end, the cost is $1.801 billion. Again, the order of magnitude of the cost estimate is not much affected.

The results are somewhat more sensitive to changes in assumptions regarding indirect costs. If the estimates of the

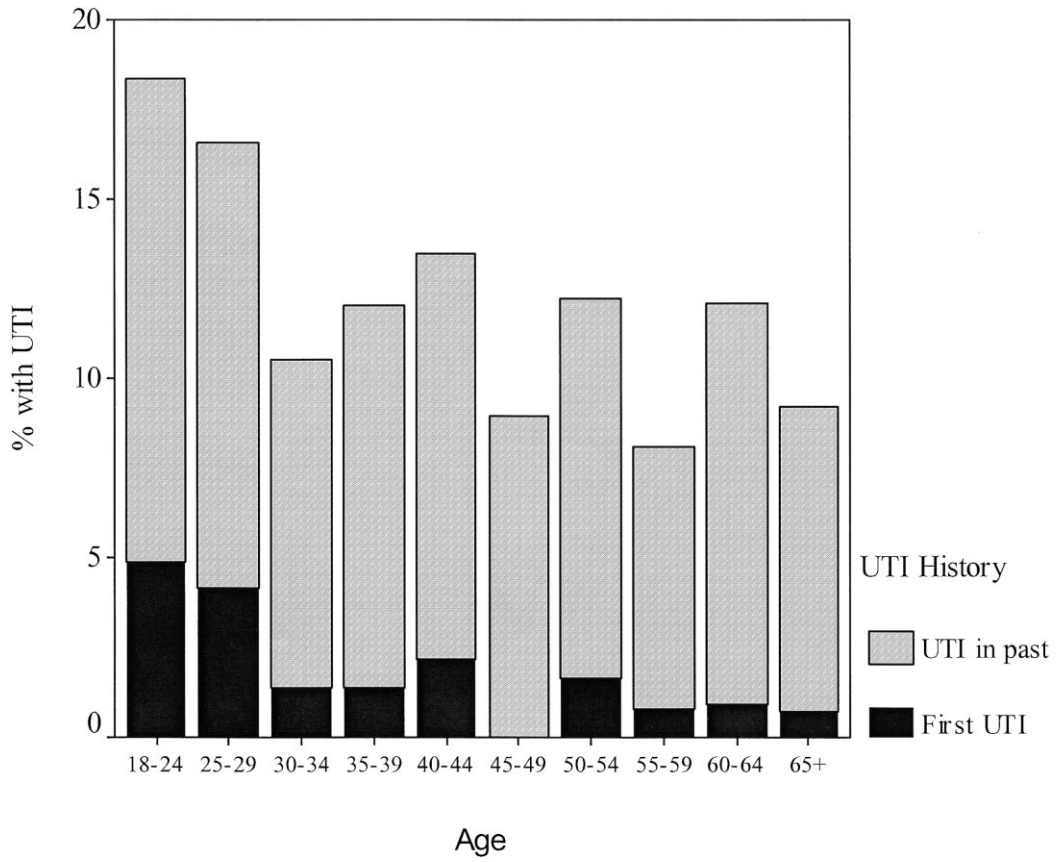

FIGURE 1. Self-reported incidence of physician-diagnosed urinary tract infection during the previous 12 months by age and history of urinary tract infection among 2000 United States women participating in a random digit dialing survey. The average standard error for the total incidences in each of the age groups is 2.3%.

degrees of disability associated with the three outcomes of the disease (bed days, other days of restricted activity, and other days with symptoms) are all halved, the total annual cost is reduced from $1.6 billion to $1.1 billion, still a rather large sum.

The methods used for estimating costs in 1995 can also generate estimates for years beyond. In making such projections, we assumed that the number of cases (CAS) would grow at 0.8% annually, in line with the expected growth rate of the U.S. population as a whole; that wages ($PW and $UW), travel and child-care expenses ($TC) and clinic charges ($DV) would all grow at 2% annually; and that prescription charges would grow at 5% annually, as antibiotic resistance creates demands for new and more expensive drugs. The assumed growth rates of the monetary parameters were expressed in real terms (i.e., after adjustment for general inflation). For purposes of our projection, the other parameters shown in Table 1 were assumed to stay at their 1995 values.

On these assumptions, the annual social cost of UTI cases with prescriptions rises from $1.6 billion in 1995 to $2.8 billion in 2014. The total cost over the 20 years is $42.98 billion, if we give equal weight to a dollar spent in 1995 and a dollar spent in 1996 or later (no discounting of future costs). If the costs occurring after 1995 are discounted at 5% annually, the total 20-year cost has a present value of $25.5 billion; at a 10% discount rate, the total is $16.7 billion.

DISCUSSION

UTI occur with high frequency in all age groups but primarily among the young: 17.5% of 18- to 24-year-olds reported at least one presumed UTI in the previous 12 months. By age 26 one-third had had at least one UTI. While the incidence we found in the general population (10.8%) is much smaller than the 0.5 per person-year among sexually active women aged 18 to 40 using a Seattle health maintenance organization who had recently changed contraceptive method (3), this probably is due to the more select nature of the population studied in Seattle. Seattle women who

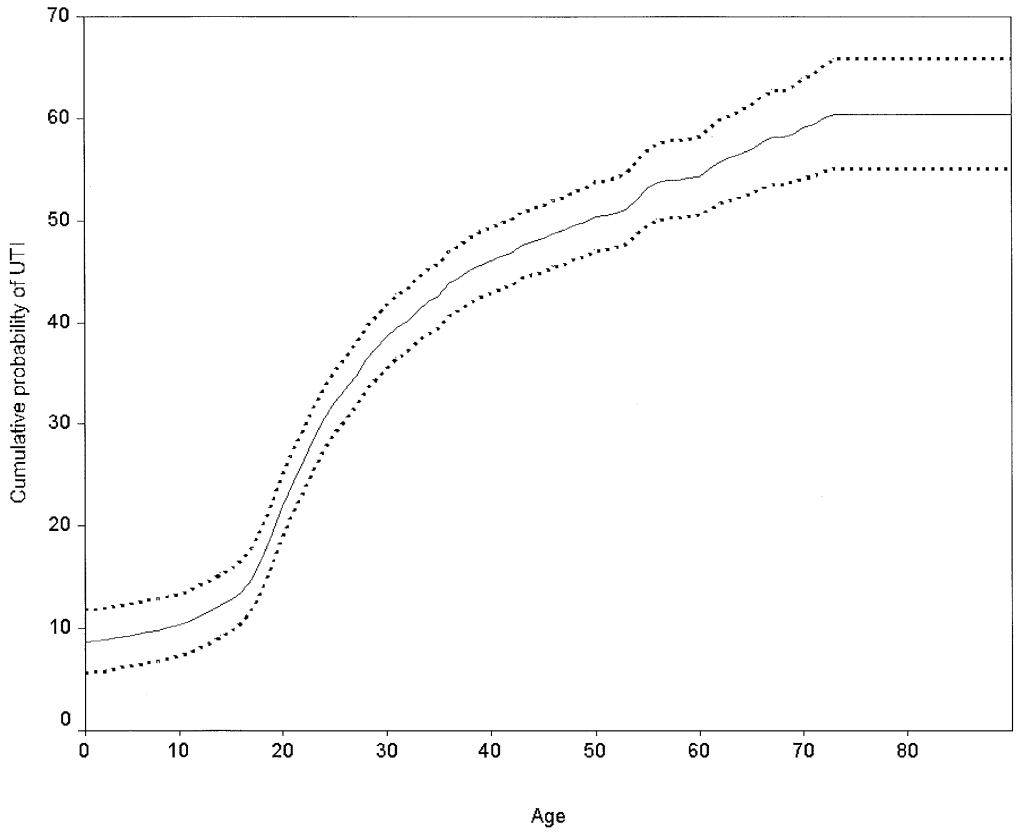

FIGURE 2. Cumulative probability of self-reported physician-diagnosed urinary tract infection by age among 2000 United States women participating in a random digit dialing survey. 95% Hall-Wellner confidence bands are given by dashed lines.

had not had intercourse in the past 7 days had a UTI incidence of 0.1 per person year, and Seattle women without a previous UTI had an incidence of 0.3 per person year, numbers more comparable to the 14.1% incidence we observed among 18- to 40-year-olds. The incidence found in this study is also lower than we observed in unpublished data from a random sample of 661 women attending college who completed a mailed survey. In that study 3% of women age 17 to 62 reported a UTI during the past month and 2% reported taking medication to treat a UTI during the past two weeks. Assuming constant rates throughout the year, the annual incidence of diagnosed UTI would be 36% (3%/month × 12 months) with 48% annually (4%/month × 12 months) taking UTI medication; these estimates are consistent with those found in the Seattle study.

In contrast with studies of the prevalence of bacteriuria (16, 17), we did not find that self-reported history of presumed UTI increased with age. Because the prevalence of symptomatic UTI by age is not well documented, particularly among older women, further studies are needed to evaluate the veracity of our finding. One large cross-sectional survey measured both bacteriuria and urinary symptoms among women aged 16 to 69; the prevalence of bacteriuria increased with age but the prevalence of urinary symptoms did not (16). Among women in a rural general practice in England, women over 55 had lower rates of frequency and dysuria (18) and post-menopausal women were less likely than pre-menopausal women to report seven or more episodes of urinary symptoms in the past two years (19).

Our UTI incidence and cumulative probability estimates are based on self-report. Some women who reported a presumed UTI may not really have had one during the past 12 months, because their recall of the diagnosis or timing of diagnosis was incorrect, or their UTI was not appropriately diagnosed, or both. Moreover, if women with UTI were more likely to participate in the study, we will have overestimated UTI incidence. However, our estimates of self-reported lifetime risk (60.4%) are similar to those of other samples representative of the United States (2). Further, recruitment material did not mention UTI but "an important public health problem among women" and more particularly "vaginal yeast infections."

UTI risk varies by the presence of diabetes, and other co-morbidities (20). As we did not explicitly measure these factors in our survey, if persons with these underlying risk

TABLE 2. Annual cost of urinary tract infection, 1995

Cost	Cost ($ m.)	Reference[a]
Direct costs		
Medical expense:		
Clinic charges	385	CAS*PD*$DV
Prescriptions	89	CAS*$P
Non-medical expenses:		
Travel and child-care for visits	77	CAS*PD*$TC
Output lost due to time spent for visits	108	CAS*PD*HDV*$UW
Total direct costs	659	
Indirect costs		
Output lost due to disability		
During bed days	300	CAS*DB*$L[PE*SBE + (1 − PE)*SBI]
During other days of restricted activity	300	CAS*DR*$L[PE*SRE + (1 − PE)*SRI]
During other days with symptoms	336	CAS*DS*$L[PE*SSE + (1 − PE)*SSI]
Total indirect costs	936	
Total costs	1,594	

[a] Notation defined in Table 1.

factors are over- or under-represented our incidence estimates will be biased.

We estimated that 11.3 million United States women had a presumed UTI in 1995 for which they took a prescription medication. Our estimate is substantially higher than the 7.3 million visits by women for UTI or cystitis estimated by the National Ambulatory Medical Care Survey (1). The discrepancy may reflect self-diagnosis and treatment following phone consultation with a physician, or using antibiotics previously obtained for that purpose. Prescription of anticipatory or prophylactic antibiotics for women with recurring UTI is a standard medical practice (20).

Our estimates of the total direct costs of UTI treatment and work loss in 1995 ($1.6 billion) are somewhat higher than that of Johnson and Stamm for 1987 ($1 billion) (21). Inflation accounts for part of the difference. In addition, we included costs associated with time lost from work, assumed a larger number of UTIs, but assumed much smaller medical expenses ($58 per episode for clinic charges and antibiotics versus $140), presuming as is current medical practice that most UTIs are diagnosed without benefit of urine culture. We also assumed that all women were treated with either trimethoprim-sulfa or macrodantin/nitrofurantoin, although we know that other more expensive drugs are often used. However, the overall cost was not very sensitive to drug price, increasing only 12% with a $16 increase in drug price.

The estimated annual social costs of UTI are high, even though our estimates omit unmeasured costs such as adverse reactions to therapy, and intangibles such as pain and emotional distress to the affected woman. While several risk factors for UTI have been identified in the past 20 years, asking women to modify their frequency of vaginal intercourse—the strongest risk factor—seems unreasonable at best, and other risk factors, such as diaphragm use, are practiced by relatively few women (20). If a vaccine were developed that would prevent either initial or recurrent UTI the net benefits to society would be substantial, even at a developmental cost of one billion dollars.

In conclusion, UTI affects 10.8% of all United States women annually, and imposes a substantial burden upon society. Investing in research focusing on UTI prevention would be a worthwhile societal investment, ultimately leading to a reduction in UTI costs and disease impact.

The work was supported, in part, by an unrestricted educational grant from Pfizer Corporation. The telephone survey was conducted by Yankelovich Partners.

REFERENCES

1. National Center for Health Statistics. Unpublished data, National Ambulatory Medical Care Survey, 1995.
2. Zielske JV, Lohr KN, Brook RH, Goldberg GA. Conceptualization and measurement of physiologic health for adults. Urinary tract infection [report]. The Rand Corporation; R2262/16-HHS; 1981.
3. Hooton TM, Scholes D, Hughes JP, Winter C, Roberts PL, Stapleton AE, Stergachis A, Stamm WE. A prospective study of risk factors for symptomatic urinary tract infection in young women. N Engl J Med. 1996;335:468–474.
4. Foxman B, Marsh JV, Gillespie B, Sobel JD. Frequency and response to vaginal symptoms among white and black women: Results of a random digit dialing survey. J Women's Health. 1998;7:1167–1174.
5. Foxman B, Frerichs RR. Epidemiology of urinary tract infection I. Diaphragm use and sexual intercourse. Am J Public Health. 1985: 75:1308–1313.
6. McGinley L. FDA urged to bar nonprescription sales of acyclovir. Wall Street Journal January 13, 1995: B4.
7. Rubin N, Foxman B. The cost-effectiveness of placing urinary tract infection treatment over the counter. J Clin Epidemiol. 1996;49: 1315–1321.
8. Hersch J, Stratton LS. Housework, wages, and the division of housework time for employed spouses. Am Econ Review. 1994;84:120–125.

9. Institute for Social Research, University of Michigan. Panel Study of Income Dynamics, 1992. Analysis of data from www.isr.umich.edu/src/psid.
10. Medical Economics Corporation. 1995 Drug Topics Red Book. Montvale, NJ; 1995.
11. Ikaheimo R, Siitonen A, Heiskanen T, Kakkainen U, Kuosmanen P, Lipponen P, Makela PH. Recurrence of urinary tract infection in a primary care setting: Analysis of a 1-year follow-up of 179 women. Clin Infect Diseases. 1996;22:91–99.
12. U.S. Bureau of the Census. Resident Population of the United States: Estimates, by Age and Sex. (Nov 3 1997). <www.census.gov/population/estimates/nation/intfile2-1.txt>.
13. Harris EK, Albert A. Survivorship Analysis for Clinical Studies. New York: Marcel Dekker, Inc; 1991.
14. SAS Institute Inc. SAS Language Guide for Personal Computers, Version 6. Cary, NC: SAS Institute Inc; 1995.
15. Dean AG, Dean JA, Burton AH, Dicker RC. Epi Info, Version 5: A Word Processing, Database and Statistics Program for Epidemiology on Microcomputers. Centers for Disease Control, Atlanta, GA; 1990.
16. Kunin CM, McCormack RC. An epidemiologic study of bacteriuria and blood pressure among nuns and working women. N Engl J Med. 1968;278(12):635–642.
17. Evans DA, Williams DN, Laughlin LW, Miao L, Warren JW, et al. Bacteriuria in a population-based cohort of women. J Infect Disease. 1978;138:768–773.
18. Jolleys JV. The reported prevalence of urinary symptoms in women in one rural general practice. Br J Gen Pract. 1990;40:335–337.
19. Jolleys JV. Factors associated with regular episodes of dysuria among women in one rural general practice. Br J Gen Pract. 1991;41:241–243.
20. Kunin CM. Urinary Tract Infections. Detection, Prevention, and Management. 5th ed. Baltimore, MD: Williams & Wilkins; 1997.
21. Johnson JR, Stamm WE. Diagnosis and treatment of acute urinary tract infections. Infect Dis Clin N Am. 1987;1:773–791.