Predictors of hysterectomy: An Australian study

Susan A. Treloar, PhD,[a] Kim-Anh Do, PhD,[a] Vivienne M. O'Connor, MB, ChB,[b] Daniel T. O'Connor, MB, BS,[c] Margaret A. Yeo, MPH,[a] and Nicholas G. Martin, PhD[a]

Brisbane, Queensland, Australia

OBJECTIVE: We evaluated the relative importance of predictors of hysterectomy.
STUDY DESIGN: A questionnaire survey of an Australia-wide sample of adult female twins was conducted; self-report data were validated against reports from treating physicians.
RESULTS: A total of 3096 women (94%) and 366 physicians (87%) responded. The sensitivity of patient report of hysterectomy was 98.2%. Best predictors of hysterectomy were endometriosis (odds ratio 4.85, 95% confidence interval 3.17-7.43), medical consultation for menorrhagia (odds ratio 3.55, 95% confidence interval 2.47-5.12), joint effects of fibroids with medical consultation for chronic or persisting pelvic pain (odds ratio 3.34, 95% confidence interval 1.42 to 7.87), having smoked >40 cigarettes per day (odds ratio 3.24, 95% confidence interval 1.10-9.55), joint effects of fibroids with consultation for menstrual problems (odds ratio 2.61, 95% confidence interval 1.36-5.01), and tubal ligation (odds ratio 1.77, 95% confidence interval 1.31-2.39). Less-important predictors were age and higher education level (protective).
CONCLUSION: Consulting a physician about pelvic pain and menstrual problems, especially heavy bleeding, are recognized steps toward hysterectomy. Of particular interest for future genetic analyses are the high odds of hysterectomy for women with endometriosis, fibroids, or menorrhagia. (Am J Obstet Gynecol 1999;180:945-54.)

Key words: Hysterectomy, validation, predictors, risk factors

Studies investigating pathways to hysterectomy performed for benign and nonemergency conditions have been rare. Clinical reviews have focused on the impact of new or changing techniques available to surgical practice and on developments in medical and pharmaceutical treatments. A health policy agenda concerning appropriate use of health care resources has influenced many other reviews of rates and indications. The first phase of the current study, with use of a genetic epidemiologic approach, attempted to identify predictors of hysterectomy and their causal role with use of data on Australian twins.[1] To our surprise, we found strong evidence for genetic factors influencing liability to hysterectomy, accounting for 66% of the total variance. Furthermore, these genetic influences were stable across birth cohorts in spite of differences in incidence resulting from aging and other factors such as secular changes in surgical practice and health service financing.[1] We therefore hypothesized that the high heritability of hysterectomy reflects genetic influences on gynecologic factors that are commonly indications for elective hysterectomy. Here we describe a survey implemented to collect data to test this hypothesis. In this study we focus on the relative importance of risk factors for hysterectomy and the phenotypic relationships between them. Genetic analyses making full use of the twin structure of the sample will be the subject of a further study. Given this epidemiologic focus, we also aimed to test the validity of retrospective self-reported data against data obtained from medical, surgical, or pathology sources. This was achieved by requesting written consent and contact details for treating physicians and pathologists. Results of validation testing are summarized in this article.

Methods

Sample. Participants were members of a cohort of 1979 female twin pairs, ascertained originally in 1980 to 1982 from the Australian Twin Register, and followed up in 1988 to 1990.[1, 2] The current study comprised a third wave of data collection from the original cohort of female twins. In 1993 to 1994 questionnaires that focused on gynecologic conditions and hysterectomy were sent to both members of 1570 female twin pairs plus a further 158 individual female twins in incomplete pairs (3298 individuals) who were still able to be contacted and who were willing to participate in research. Individuals whose cotwins were unable or unwilling to participate were included in the sample for purposes of assessing validity of hysterec-

From the Cooperative Research Centre for Discovery of Genes for Common Human Diseases, Queensland Institute of Medical Research,[a] the Department of Obstetrics and Gynaecology, University of Queensland,[b] and St Andrews Hospital.[c]
Supported by the Mayne Bequest Fund (University of Queensland) and the Australian Gynaecological Endoscopy Society.
Received for publication May 7, 1998; revised November 9, 1998; accepted November 23, 1998.
Reprint requests: S.A. Treloar, PhD, Queensland Institute of Medical Research, PO Royal Brisbane Hospital, Queensland 4029, Australia.

0002-9378/99 $8.00 + 0 ***6/1/96055***

tomy and endometriosis report. Approval to conduct the research was obtained in June 1992 from the Bancroft Ethics Committee (Queensland Institute of Medical Research) and from the Australian Twin Registry.

Assessment. Participants were asked to complete a 4-page questionnaire ("Gynaecological Health Study") that included questions on gynecologic problems that might predispose to hysterectomy, other surgical interventions, and medical and hormone treatments. Potential predictors of hysterectomy assessed at this study wave included age; parity; medical consultation for chronic pelvic pain; problems conceiving; menstrual problems (painful, heavy, or irregular menses; intermenstrual, postcoital, or postmenopausal bleeding); a history of endometriosis, pelvic inflammatory disease, or fibroids; and investigations or interventions including laparoscopy, colposcopy, curettage, endometrial ablation, treatment for an abnormal cervical smear, tubal ligation, or other abdominal surgery.

Data on alcohol use, smoking, highest educational level attained, and major lifetime occupation were available from the 1988 to 1990 data set on the same individuals. Smoking variables included highest report of average cigarette use per day and pack-years of smoking. The alcohol variables were ever having consumed alcoholic drinks (yes/no) and average daily consumption of alcohol in grams, calculated from average weekly consumption (of smallest and largest amounts reported at different study waves).

Validation. Participants were asked to sign an attached consent form to allow contact with nominated treating medical practitioners (general practitioners, current and at the time of diagnosis, gynecologists, surgeons). Consent was requested for the research team to contact their current family physicians or general practitioners, as well as other physicians who had treated them, if they had had a hysterectomy or endometriosis. Where women gave their consent and reported either hysterectomy or endometriosis, questionnaires were sent to physicians beginning in June 1994. Validation of self-reported hysterectomy or endometriosis was sought where possible from the nominated specialist involved. If that person could not be contacted, the next contact attempted was the general practitioner involved in the treatment of the relevant condition, then the hospital or pathology laboratory. If no other medical source responded, the current general practitioner was contacted. Nominated medical sources (physicians) were mailed a 2-page questionnaire with an explanatory cover letter and a copy of the patient's written consent. Physicians who had not responded after 6 weeks were telephoned by a research nurse to encourage participation.

Data analysis. Where possible, we combined self-report data from the women and reports from their physicians by computing new variables to jointly maximize validity and the number of cases. We used information from medical, surgical, or pathology reports where available; where not available, we looked for corroborating self-report evidence supporting diagnosis of conditions (for example, a laparoscopy as support for a diagnosis of endometriosis). If there was contradictory information from medical-surgical-pathology reports for the presence of a self-reported gynecologic condition and no other supporting evidence, the woman's report was considered negative rather than positive for the condition in our multivariate data analyses.

The statistical package SAS 6.11[3] was used for preliminary and phenotypic data analyses. We then used the decision tree method Classification and Regression Trees (CART)[4] as an exploratory tool to identify significant main effects and interactions in relation to hysterectomy. Two branches are allowed from nonterminal nodes, with participants being split and classified into one or the other branch. Through recursive partitioning and pruning, the method produces a parsimonious tree as the best solution, but lowering the relative cost allocated to classifying hysterectomy results in a more informative tree. Identification of statistical predictors (see Fig 1) is based on cross-validation and not on significance testing. The main advantage of CART is its ability to handle missing values effectively through the use of surrogate splits.

Finally, we analyzed the significance and relative importance of predictor variables in logistic regression models with use of both the logistic procedure and the generalized linear models procedure (with a response equal to the binomial proportion of hysterectomies divided by responses) in SAS 6.11.[3] CART results were used to inform selection of main effects and interactions for testing. In preliminary model construction we confirmed which main effects were individually statistically significant predictors of hysterectomy. Then, because relationships between variables were complex, final model construction was performed in 2 steps: (1) logistic regression with use of backward selection identified variables with significant main effects for retention in the model and (2) interactions were included with main effects and tested for significance.

Results

Response. A total of 3096 women returned a questionnaire that was at least partially completed, giving an individual response rate of 94%. The respondents comprised 1431 pairs where both cotwins responded and 234 single twins, a pairwise response rate of 91%. Major reasons for nonresponse were death (n = 24) or they were uncontactable (n = 93) or too busy to participate (n = 76).

Of women reporting hysterectomy (n = 524), 439 (86%) gave consent to approach relevant physicians and response was obtained from 366 (70%) potential medical sources of validation. The majority (n = 197 or 54%) were specialists who had treated the patient in relation to hysterectomy; current general practitioners formed the next

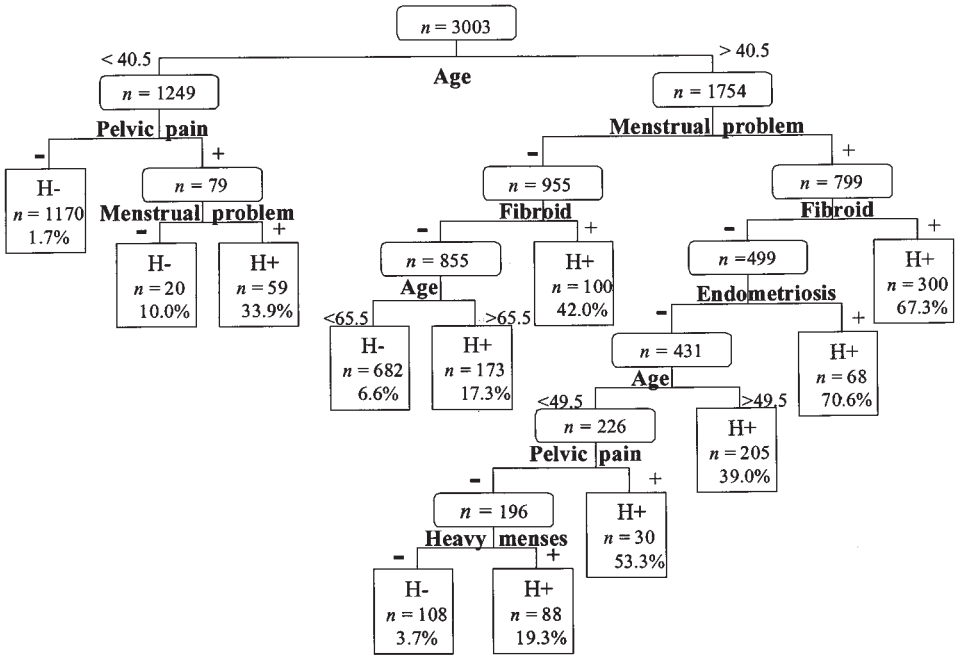

Fig 1. Predictors of hysterectomy from CART analysis. +, Positive on predictor (*boldface type*); –, negative on predictor (*boldface type*); *H+*, predicted hysterectomy (proportion ≥10%); *H–*, predicted no hysterectomy (proportion ≤10%); *%*, percentage of actual hysterectomies from number predicted *H+* or *H–* in *box*.

largest group (n = 86 or 24%), 56 were "other sources," which largely comprised hospital and pathology services, 24 (7%) were general practitioners who had treated in relation to hysterectomy, and the balance were 2 specialists and one general practitioner treating the patient in relation to endometriosis. Fifty-five percent of physician questionnaires were returned completed within 6 weeks (most with substantial clinical detail and pathology results attached) without any need for follow-up.

Characteristics of respondents. Respondents were aged between 29 and 91 years at the date their questionnaires were returned, with a mean age of 46.3 ± 12.6 years and a median of 43 years. Increasing age or infirmity are factors in nonresponse in such longitudinal studies and eligible nonresponding women were significantly older than respondents ($P < .001$). No significant difference was noted between respondents and nonrespondents for highest education level reached (reported at 1988 to 1990 survey). Further sociodemographic details of the sample are available on request.

At the time of response to the survey, 64% had had a menstrual period in the previous 12 months. There was a substantial lifetime prevalence of menstrual problems that led women in the responding sample to seek medical help (see Table I). There was no significant similarity between reasons for first and second laparoscopy, and a number moved, for example, from endometriosis as the reason for first investigation to infertility or cysts. Ages of onset and of help seeking varied between symptoms and conditions (see Table I).

Hysterectomies. Hysterectomy was reported by 524 women (17.4% of question respondents, n = 3003) and affirmed in 329 (97.6%) of 337 medical responses (simple κ coefficient 0.9, 95% confidence interval 0.83-0.97). Twenty-nine physicians provided no information about hysterectomy. The reports of 6 physicians contradicted positive patient self-report; 2 physicians were uncertain whether the patient had had a hysterectomy. In 2 cases in which the patient negatively reported hysterectomy, the physician's report was positive. In both cases year and route of hysterectomy were provided and the physician's report was therefore accepted. Of the 6 negative medical reports, 2 were from specialists and 4 were from current general practitioners. Checking the patient's report and the physician's report led to the conclusion that the physician either did not know about the hysterectomy in the case of current general practitioners, had seen the woman before she had decided to have a hysterectomy, or had responded "no" rather than "don't know." In all cases the women had given details about the hysterectomy, their ages at the time, the route, and whether ovaries were removed and had named a hospital where the surgery was performed. In these cases the self-report was considered valid.

Medical reports of age at hysterectomy correlated strongly ($r = 0.9$, $P = .0001$) with ages reported by women. Respondents who had a hysterectomy were older than respondents reporting no hysterectomy, with mean age at response 55 ± 11 years compared with 45 ± 12 years. Years since hysterectomy ranged from less than 1 year (n = 5)

Table I. Gynecological problems and procedures reported by survey respondents

	Reported positive		*Age at onset (y)*		
	No.	*%*	*Range*	*Median*	*No.*
Problems					
Menstrual problems*	1266	41.3	11-54	25	365
Painful menses	619	77.7	9-47	18	276
Heavy menses	650	80.2	11-55	31	277
Irregular menses	394	64.0	9-53	25	181
Unusual bleeding	334	58.9	10-65	33	143
Other	100	28.7	16-55	32.5	38
Pelvic pain†	354	11.6	9-60	27	300
Endometriosis	215	7.2	14-49	30	93
Fibroids	469	15.6	18-63	38	219
Problems conceiving*	390	12.9	18-44	27	294
Procedures					
Curettage, first	1262	42.8	13-72	30	1011
Curettage, second	253	8.6	17-58	32	253
Tubal ligation	725	24.3	22-50	33	633
Hysterectomy	524	17.4	18-76	40	428
Laparoscopy, first	444	14.8	17-60	31	357
Laparoscopy, second	65	2.2	19-60	32	65
Cholecystectomy	269	8.9	18-78	37	257
Colposcopy, first	240	8.2	17-79	33	227
Colposcopy, second	21	0.7	23-52	33	21
Treatment for abnormal smear/precancer	218	7.3	19-62	31	176
Endometrial ablation	46	1.5	22-73	39	39

*Physician was consulted about this problem.
†Persistent or chronic pelvic or abdominal pain.

Table II. Prevalence of hysterectomy by respondent age group

		Hysterectomy	
Age group (y)	*Respondents (No.)*	*No.*	*% of age group*
29-35	588	9	1.5
35-39*	539	23	4.3
40-44	498	75	15.1
45-49*	397	85	21.4
50-54	274	75	27.4
55-59	198	79	39.9
60-69	317	118	37.2
70-79	155	54	34.8
80-91	27	8	29.6
TOTAL	2993	526	—

*Age groups 35-39 and 45-49 years each contain 1 hysterectomy that was not reported by the woman but was reported by medical source.

to 54 years (n = 1), with mean time since hysterectomy 14 ± 10 years and median 12 years. Prevalence of hysterectomy by age group of respondents is shown in Table II.

Details of hysterectomies are shown in Table III. Abdominal rather than vaginal hysterectomy was significantly more common in nulliparous women ($P = .009$) but was not associated with level of parity. Route was also significantly associated with patient's age at hysterectomy ($P = .013$), with the vaginal route more common in women younger at time of hysterectomy than in older women. Age at response to survey was not associated with the route of hysterectomy. There was significant consistency between patient and medical reports on hysterectomy route, oophorectomy, and timing of oophorectomy.

Interestingly, 45.8% women reported oophorectomy, 35.9% at the time of hysterectomy and 9% as a separate procedure. The only significant association between indications for hysterectomy and timing of oophorectomy was when the hysterectomy was performed because of ovarian cancer ($P = .008$). This procedure is usually undertaken for disease involving the ovaries or for the prevention of future ovarian cancer. Oophorectomy was significantly associated with hysterectomy for inflammation of pelvic organs ($P = .001$), endometriosis ($P = .001$), cancer of the uterus ($P = .004$) or ovaries ($P = .017$), or other tumor or cyst ($P = .001$). No association was found between oophorectomy and hysterectomy because of fibroids, prolapse, abnormal smear, other cancer, or hysterectomy for birth control reasons. No association was found between indications and whether oophorectomy was unilateral or bilateral. Mean age at bilateral oophorectomy performed at hysterectomy (42.98 ± 9.80 years) was significantly greater ($P = .034$) than mean age at the time of unilateral oophorectomy (39.27 ± 9.83 years).

Reasons for hysterectomy. Women were asked about reasons for their hysterectomies. Results are shown in Table IV. Most women gave only 1 reason, but 95 gave more. If fibroids were not the most important reason, they tended to be the second. Where multiple reasons were offered and ranked in order of importance (n = 159), fibroids most fre-

Table III. Features of hysterectomies reported by women and physicians and agreement between reports

	*Women (n = 524)**		*Physicians (n = 329)*		
Features	*No.**	*%*	*No.*	*%*	*κ (n = 329)*
Route					
Abdominal	426	81.3	261	79.3	0.8†
Vaginal	96	18.3	45	13.7	—
Uncertain	0	0.0	7	2.1	—
Oophorectomy					
Yes	240	45.8	122	37.1	0.8†
Laterality					
Bilateral	124	23.7	75	22.8	0.7†
Unilateral	98	18.7	43	13.1	—
Ovary					
Right	36	6.9	18	5.5	0.6†
Left	42	6.9	21	6.4	—
Uncertain	5	1.0	1	0.3	—
No	272	51.9	177	53.8	—
Uncertain	5	1.2	9	2.7	—
Timing					
With hysterectomy	188	35.9	95	28.9	0.8†
Separate surgery	47	9.0	17	5.2	—
Uncertain	0	0	1	0.3	—

*Only 524 self-reported hysterectomies were included because respondents not reporting hysterectomy did not answer these questions. Missing data account for any gap between percentage totals and 100% for each question.
†95% Confidence intervals for simple κ coefficients in final column, descending: 0.7-0.9, 0.7-0.9, 0.6-0.9, 0.23-0.9, 0.6-1.0.

quently ranked first (n = 44). Prolapse (n = 27) and endometriosis (n = 23) were the next most common principal reasons. Where endometriosis was a main reason for hysterectomy, physicians were asked whether the key precipitating factor leading to hysterectomy was the patient's decision, persisting symptoms, intolerance of medical treatment, or another reason. Most respondents (68.3%) reported that persistence of symptoms was the key factor. This was followed by patient decision (11.9%); other reasons were infrequent.

Mean age at hysterectomy varied significantly between groups who had a hysterectomy for different benign conditions ($F = 9.34$, degrees of freedom 4, $P = .0001$). Mean age at hysterectomy was highest for those reporting uterine prolapse (43.8 ± 9.83 years) and fibroids (mean 41.62 ± 6.52 years) as reasons for hysterectomy. These mean ages at hysterectomy were significantly higher than those for women reporting hysterectomy for birth control (mean 37.00 ± 6.95 years) and inflammation of pelvic organs (mean 36.07 ± 4.92 years). The latter 2 conditions differed significantly neither between each other nor with endometriosis (mean 37.77 ± 5.20 years). Mean age at hysterectomy did not differ between groups reporting fibroids or endometriosis.

Correspondence between patient and medical reports. Fibroids and heavy menstrual bleeding or pain were the most frequently reported reasons for hysterectomy in patient reports and medical reports. Agreement between patients and physicians differed substantially between indications (Table IV), with good agreement on endometriosis, prolapse, and ovarian cancer but poor agreement on reasons such as fibroids, menorrhagia, and dysmenorrhea. Patients and physicians were asked to specify the principal reason for hysterectomy if there was more than one. Frequencies were too low for proper assessment of agreement for many conditions. Where there were multiple reasons, different perspectives may have led physicians and patients to give different priorities to reasons. Patient reports of fibroids as the principal reason for hysterectomy were affirmed by medical report in all but 3 cases, although numbers were not large at this level of analysis.

Correspondence between women's and physicians' reports of problems before hysterectomy was more variable than for reasons for hysterectomy. More than 85% of physician reports confirmed patient-reported chronic or persistent abdominal or pelvic pain (κ = 0.4, 95% confidence interval 0.3-0.6); agreement on uterine prolapse was reasonable (κ = 0.7, 95% confidence interval 0.5- 0.8) but lower for urinary incontinence (κ = 0.5, 95% confidence interval 0.3-0.6). The only problem where no significant association was found between women's and physicians' reports (κ = 0.1, 95% confidence interval –0.1 to 0.3) concerned persistent vaginal discharge before hysterectomy; there was a high proportion of false-positive reports. Patient-reported urinary incontinence was affirmed by less than 40% of physicians, suggesting that it might not have been reported to the physician, it was not recorded, or it was not considered as significant as other symptoms.

Histologic reports were included for 237 (68.3%) medical questionnaires returned in cases of hysterectomy (n = 347), allowing further assessment of validity. Findings noted in histologic reports are shown in Table V. Overall, there was no significant association between patient-reported most important reason for hysterectomy and

Table IV. Reasons for hysterectomy reported by women and physicians

	Women (n = 524)		*Physicians (n = 366)*			
*Reasons for hysterectomy**	*No.*	*%*	*No.*	*%*	*Interrater reliability (κ)*	*95% Confidence interval*
Fibroids	205	39.1	119	32.5	0.3	0.1-0.5
Menorrhagia with or without dysmenorrhea	164	31.3	101	27.6	0.2	0.0-0.4
Prolapse	104	19.8	27	7.4	0.6	0.4-0.8
Other reason†	85	16.2	63	17.2	—	—
Endometriosis	74	14.1	44	12.0	0.7	0.5-0.9
Other tumor or cyst	51	9.7	19	5.2	0.5	0.2-0.8
Inflammation of pelvic organs	39	7.4	23	6.3	0.4	0.1-0.7
Abnormal smear or precancer	22	4.2	8	2.2	0.4	0.1-0.8
Ovarian cancer	18	3.4	2	0.5	0.6	0.2-1.0
Cervical cancer	13	2.4	0	0	—	—
Uterine cancer	11	2.1	3	0.8	0.5	0.0-1.0
Birth control	8	1.5	2	0.5	—	—
Cancer of other area(s)	6	1.1	1	0.3	0.5	0.0-1.0
Don't know	4	0.8	0	0	—	—
Dysmenorrhea minus menorrhagia	3	0.6	6	1.6	—	—

"Other" also included anemia, bladder repair, congenital abnormality, dyspareunia, ectopic pregnancy, infertility, enlarged uterus, dysfunctional uterine bleeding, pelvic inflammatory disease and associated pain, polyps or cysts, and premenstrual tension.

*More than 1 reason could be specified.

†Forty-one percent of "other" reasons reported by physicians specified adenomyosis, which was not listed as a response option.

whether pathologic conditions were noted in the histologic report. However, a normal rather than a pathologic finding was significantly associated with hysterectomy reported by patients for birth control reasons ($P = .006$), because of fibroids ($P = .021$), prolapse ($P = .029$), endometriosis ($P = .039$), or medical consultation for unusual menstrual bleeding ($P = .034$). Fibroids was the patient-reported diagnosis least likely to be supported by pathology result. Physicians reported dysfunctional uterine bleeding (including menorrhagia) in 87.1% of women. There was a significant association ($P = .001$) between dysfunctional uterine bleeding and fibroids reported by physicians as a reason for hysterectomy, but this included women with nonsignificant fibroids. Histologic reports were assessed for the significance of any fibroids found (significant, more than 1 at >1.5 cm; nonsignificant, 1 at 1 cm or more at <0.5 cm and normal-sized uterus); 54.8% of fibroids were significant and 45.2% nonsignificant according to these criteria. There was no statistically significant association between physician-reported dysfunctional bleeding before hysterectomy and whether fibroids, if present, were assessed as significant or nonsignificant from pathology results. No significant association was found between physician-reported dysfunctional uterine bleeding and the presence of fibroids irrespective of significance. Similarly, when only significant fibroids were included as "true-positive" fibroids in analysis, no significant association was found with physician-reported dysfunctional uterine bleeding.

Predictors of hysterectomy. Variables entered into analyses to determine their significance and relative importance were from questions answered by all women in the sample and were analyzed independently of reasons for hysterectomy. All were categoric apart from age at time of response, pack-years of cigarette smoking, and average alcohol consumed per day (grams). Binary (yes/no) variables were created for parity (parous/nulliparous), low parity (1 to 2 births), high parity (>3 births), low educational level reached at 1988 to 1990 survey (<11 years' schooling only), high educational level (tertiary, technical, college, or university education), ever smoked, having smoked >20 cigarettes per day, having smoked >40 cigarettes per day, and having consumed alcoholic drinks. Significant ($P < .001$) were age at survey response; high educational level reached (negative); (nulli)parity; low parity (negative); persistent/chronic abdominal/pelvic pain and having consulted a physician about this pain; having consulted a physician about difficulty conceiving; consulting a physician about menstrual problems including painful menses, heavy menses, and unusual bleeding; endometriosis; fibroids; and surgical procedures of laparoscopy, curettage, tubal ligation, cholecystectomy, and endometrial ablation. Only procedures performed before hysterectomy were included in the analyses. Treatment for an abnormal cervical smear was significantly associated with hysterectomy ($P = .03$). Having had a colposcopy, having smoked, pack-years of smoking, smoking >20 cigarettes per day, having consumed alcohol, and average alcohol consumption per day (grams) were not significantly associated with hysterectomy.

Decision tree analysis. CART randomly selected two thirds of the total sample data to construct the classification procedure and the remaining disjoint set was used for evaluation. A sequence of classification trees was produced. The most statistically parsimonious model (with the smallest unbiased error estimate) split the sample at

40.5 years: for the younger women having seen a physician about chronic or persistent pelvic or abdominal pain was the best predictor, for the older group having seen a physician about a menstrual problem, or if not, a diagnosis of fibroid(s) was predictive.

However, we chose an equivalent tree (with a similar unbiased error estimate), which was more informative, including more variables and portraying 12 terminal nodes. A final resubstitution tree is given in Fig 1. The overall sensitivity and specificity were 86.5% and 77.1%, respectively. This tree suggested that for women <40.5 years old the key predictor of hysterectomy was consulting a physician about 1 or more menstrual problems where medical assistance had also been sought for chronic or persistent pelvic or abdominal pain. For women aged >40.5 years there were more predictive "risk" situations. The first, for women who had neither seen a physician about menstrual problems nor had a fibroid diagnosed, hinged on their ages being >65.5 years old. The second and third were whether they had had a fibroid diagnosed and whether they had sought help for menstrual problems. If they had not had a fibroid, hysterectomy was then predicted by endometriosis; if no fibroids or endometriosis had been diagnosed, then being aged >49.5 years was itself predictive. For those <49.5 years old the situation was like that for the younger group in the very first split in the tree: medical consultation about chronic pelvic pain was the next predictor. The classification tree ultimately identified women who had not sought medical help for pelvic pain, if they were aged in their forties, had neither fibroids nor endometriosis diagnosed, but had seen a physician about heavy menstrual bleeding.

Statistically significant predictors of hysterectomy. We used logistic regression to identify the best predictors of hysterectomy and to assess their relative importance. Although nearly all had been individually significant predictors, when entered together the significant main effects were the variables identified in the decision tree plus very heavy smoking history, tubal ligation, and higher educational level. Although these latter variables were not selected in the CART exploration, they had been competitor variables for certain data splits. Having smoked more than 40 cigarettes a day versus lower/no cigarette consumption was included, although its level of significance was not high and it was the last to be selected in stepwise analysis. This suggests a threshold effect applicable to a very high level of smoking, because including the fifth category of 21 to 40 with the highest level resulted in nonsignificance. Because only 29 women fell into the >40 cigarettes category and splitting this would lead to very small cell sizes, we did not include it in the CART analysis.

After identification of main effects, given the complexity of the data, possible interactions between variables were tested for addition to the model. Interactions occur when the effect of a variable is dependent on the level or occurrence of another variable. Two independently significant interactions were added: fibroids dependent first on whether medical consultation had been sought about pelvic pain and second on whether consultation had been sought about menstrual problems. The final model is shown in Table VI. Endometriosis was the highest single main effect, whereas fibroids were only significant in the context of joint effects. Likewise, the variables of consultation about pelvic pain and menstrual problems were only significant as joint effects; nevertheless, it was necessary for them to remain in the model. Having reached tertiary education level was the only factor to have a protective effect.

The model may be interpreted by calculating odds ratios for certain combinations of the parameters. For example, after age was controlled for, high education was a protective factor for women who reported no problems. A relatively high probability of hysterectomy was found for a woman who had seen a physician about pelvic pain and also about a menstrual problem and reported fibroids—the odds ratio was 8.76 (a 90% chance), whereas for endometriosis the total odds ratio was 4.85 (an 83% chance).

Table V. Findings from histologic reports of 237 hysterectomies

Main findings	*No.*	*%*
Normal	64	27.0
Endometriosis		
Sole finding	8	3.4
Comorbid diagnoses	22	9.3
Leiomyoma	15	6.3
Other	7	3.0
Adenomyosis		
Sole finding	29	12.2
Cocondition	40	16.9
Leiomyoma		
Sole finding	26	11.0
Cocondition	53	22.4
Endometrial polyps		
Sole finding	6	2.5
Cocondition	11	4.6
Ovarian cyst		
Sole finding	8	3.4
Cocondition	14	6.1
Cervical dysplasia		
Sole finding	1	0.4
Cocondition	1	0.4
Adhesions		
Sole finding	2	0.8
Cocondition	13	5.5
Uterine cancer (sole finding or cocondition)	3	1.3
Cervical cancer (sole finding)	2	0.8
Other	3	1.3

Comment

The aim of this component of our research was to identify predictors of hysterectomy from an epidemiologic rather than a clinical sample. Our findings affirmed that women accurately reported hysterectomy; there

Table VI. Predictors of hysterectomy from logistic modeling (n = 2633)

*Parameter**	*Parameter estimate*	*SE*	χ^2	*Pr >χ*	*Odds ratio*	*95% Confidence interval for odds ratio*
Intercept	0.54	0.70	0.58	0.4460	—	—
Endometriosis	1.58	0.22	52.81	0.0001	4.85	3.17-7.43
Heavy menses†	1.27	0.19	46.23	0.0001	3.55	2.47-5.12
Fibroid(s) × Pelvic pain†‡	1.21	0.44	7.58	0.0059	3.34	1.42-7.87
Very heavy smoking	1.18	0.55	4.55	0.0329	3.24	1.10-9.55
Fibroid(s) × Menstrual problem†‡	0.96	0.33	8.35	0.0039	2.61	1.36-5.01
Tubal ligation	0.57	0.15	13.81	0.0002	1.77	1.31-2.39
Pelvic pain†§	0.47	0.35	1.83	0.1759	1.61	0.81-3.18
Fibroid(s)§	0.18	0.40	0.19	0.6621	1.19	0.54-2.63
Menstrual problem†§	0.10	0.30	0.11	0.7412	1.11	0.69-2.01
Age at survey	0.08	0.01	149.04	0.0001	1.08	1.07-1.10
High education level	–0.61	0.19	10.36	0.0013	0.54	0.37-0.79

Model fit χ^2_{2621} = 2766.7455; deviance/degrees of freedom = 0.51; log likelihood = –668.4871.
*Predictors listed in order of magnitude of odds ratios.
†Consulted physician about problem.
‡Interactions (ie, joint effects where experience of one depends on level of other).
§Nonsignificant but necessary in model because of interactions.

were few true inconsistencies between women's and physicians' reports. Careful checking revealed very few reasons why the patient's report should not be accepted and suggested that the physician's negative response in some cases may have substituted for not knowing the patient's hysterectomy status. This level of accuracy was comparable to that in the US nurses' health study[5] and is consistent with other findings suggesting that the use of self-reported hysterectomy data does not bias analyses of potentially associated factors.[6] Although we found variable levels of validation of self-reported conditions and menstrual problems, standard criteria were not defined to establish diagnoses. It is possible that retrospectivity affected women's recalled reasons for hysterectomy.

Hysterectomy is mostly undertaken to improve quality of life and is not commonly an acute life-saving procedure. The decision-making process depends not only on the clinical signs and symptoms and the presence of pathologic conditions but on the woman's preferences. Medical practitioner characteristics and preferences, available techniques,[7] and financial incentives may also be influential. Physician opinions about appropriateness of hysterectomies have been found to vary widely.[8] Nonclinical "physician" factors are suggested to be much less important than patient or clinical factors,[9] and type of hysterectomy has been reported to be influenced by patient age, race, weight, parity, and previous surgery rather than by physician preference.[10] The proportion of hysterectomies attributed to each condition may vary with study site, route, classification criteria, or options for symptoms or diagnoses.

Reasons for hysterectomy may vary not only over time[11, 12] but also with age-related changes in women themselves. Our decision tree analysis suggested ways in which this occurred, although in our data parity was not significant relative to other factors; some of the pertinent gynecologic conditions are associated with fertility problems. Our data were generally consistent with those from the large longitudinal Oxford Family Planning Association study, where the most common nominated reason for hysterectomy was fibroids, followed closely by menstrual disturbances in the absence of fibroids.[13] Although Finnish hospital data indicated that hospitalizations for fibroids, endometriosis, and bleeding disorders increased between 1971 and 1986 in women aged ≥45 years while hospitalizations for malignancies and prolapse showed no significant change,[14] we reiterate our earlier finding of genetic stability across birth cohorts in spite of differences in incidence resulting from aging and secular changes already noted.[1]

Our findings support the general statement that women have hysterectomies principally for bleeding, pain, or both.[15] Symptom relief after hysterectomy is associated with a marked improvement in the quality of life.[16] The most frequent longer-term benefit cited in another Australian study was relief from heavy bleeding (57%).[17] Dysfunctional uterine bleeding (menstrual problems with no determined underlying pathologic condition, a diagnosis of exclusion) is cited less commonly in the United States (6% to 18%)[18, 19] than in the United Kingdom (29.9%).[13] At operation up to 80% of preoperative diagnoses would be expected to be confirmed histologically, with the remainder completely normal.[15] Our histologic results showed a prevalence of adenomyosis almost identical to that reported by Vercellini et al.[20]

The epidemiology of most of the gynecologic disorders that are indications for hysterectomy is poorly understood.[14] The pathogenesis of chronic pelvic pain is perhaps most complex and may include not only gynecologic diagnoses but irritable bowel syndrome[21] and psychopathologic conditions.[22] Variations in practice for the surgical management of chronic pelvic pain may influence hysterectomy as an option.

Endometriosis, uterine fibroids, and disorders of menstruation were prevalent reasons for hysterectomy in the United States[23] and Canada.[24] Uterine fibroids are much more common than clinical diagnoses or routine pathology reports suggest.[25] The presence of small fibroids does not therefore confirm cause and effect of a woman's symptoms. Our data indicated a lower rate of verification by histologic report for leiomyomas than for other indications. Other Australian data for women having hysterectomies between 1987 and 1989 in a small area of the state of New South Wales showed that only 15% were performed for fibroids,[26] a much lower figure than the 50% reported for Finland between 1987 and 1989[14, 27] and Vienna (27.1% for 1976 to 1985).[28] In the Maine study fibroids (uterine size equivalent to 10 weeks' gestation) accounted for 54% of the women undergoing hysterectomy and 49% of a nonsurgically managed group of whom nearly 8% had a hysterectomy after 1 year.[16]

Our study supported a role for tubal ligation, as identified by others.[29, 30] Although a tendency to seek surgical solutions, rather than a "post-tubal-ligation syndrome" has been suggested,[31] our data did not support an important role for prior surgical procedures in spite of significant individual associations with other gynecologic procedures and with cholecystectomy. Covariates reported by other studies, such as social class[13] and psychologic factors,[32] were not supported by earlier data from this sample.[1] Our data suggested an association with educational level, as found in other samples.[16, 33] A history of extremely heavy smoking at any time (>40 cigarettes per day) was the only smoking or alcohol use variable that significantly predicted hysterectomy. Cancer accounted for few hysterectomies in our study, which may be explained in part by attrition because of the participation requirement of long-term enrollment with the Australian Twin Registry.

The implications of our findings depend on the extent to which the sample represents the general female population. The hysterectomy rate in this study was comparable to that reported from other Australian data. Our rate for 45- to 55-year-old women (25%) was between that reported for a randomly ascertained sample of Melbourne women (22%)[33] and a randomly selected sample of Brisbane women (31%),[34] both in the same age group. For women aged 50 to 59 years our sample's prevalence (32.6%) was similar to that (34.2%) from a community survey of women in a region of New South Wales.[35]

The 1988 to 1990 responding twin sample was representative of the Australian female population at 1986 census for occupational status and marital status.[36] Although the total sample overrepresents persons with university and senior secondary school education, this was less marked for females than for males.[36] Prevalence of recalled age at menarche[37] has also been shown to be comparable to that in the general Australian female population. Hysterectomy rates were comparable between this survey and earlier study waves.[1] However, because our sample consisted of twins, correlated observations were introduced. Analyses with only 1 twin selected at random from each pair resulted in similar estimates for covariates and the patterns of significance were the same for the full sample.

We have identified the key gynecologic predictors of hysterectomy in this Australian study. These will be tested, making full use of the twin structure of the sample, to find the extent to which their genetic influences might explain the genetic predisposition to hysterectomy.

We thank Olivia Zheng, Ann Eldridge, Lorna Greenwood, Theresa Pangan, Petra Kuhnert, Gu Zhu, and John Pearson for research and computing assistance.

REFERENCES

1. Treloar SA, Martin NG, Dennerstein L, Raphael B, Heath AC. Pathways to hysterectomy: insights from longitudinal twin research. Am J Obstet Gynecol 1992;167:82-8.
2. Treloar SA, Martin NG, Heath AC. Longitudinal genetic analysis of menstrual flow, pain and limitation in a sample of Australian twins. Behav Genet 1998;28:107-16.
3. SAS Institute. SAS/STAT user's guide version 6 edition. Cary (NC): SAS Institute; 1997.
4. Breiman L, Friedman JH, Olshen RA, Stone CJ. Classification and regression trees. Belmont (CA): Wadsworth International Group; 1994.
5. Colditz GA, Stampfer MJ, Willett WC, Stason WB, Rosner B, Hennekens CH, et al. Reproducibility and validity of self-reported menopausal status in a prospective cohort study. Am J Epidemiol 1987;126:319-25.
6. Brett KM, Madans JH. Hysterectomy use: the correspondence between self-reports and hospital records. Am J Public Health 1994;84:1653-5.
7. Harris MB, Olive DL. Changing hysterectomy patterns after introduction of laparoscopically assisted vaginal hysterectomy. Am J Obstet Gynecol 1994;171:340-3.
8. Bickell NA, Earp J, Evans AT, Bemstein SJ. A matter of opinion about hysterectomies: experts' and practicing community gynecologists' ratings of appropriateness. Am J Public Health 1995;85:1125-8.
9. Geller SE, Bums LR, Brailer DJ. The impact of nonclinical factors on practice variations: the case of hysterectomies. Health Serv Res 1996;30:729-50.
10. Dorsey JH, Steinberg EP, Holtz PM. Clinical indications for hysterectomy route: patient characteristics or physician preference? Am J Obstet Gynecol 1995;173:1452-60.
11. Grimes DA. Shifting indications for hysterectomy: nature, nurture, or neither? Lancet 1994;344:1652-3.
12. Steege JF. Indications for hysterectomy: have they changed? Clin Obstet Gynecol 1997;40:878-85.
13. Vessey MP, Villard-Mackintosh L, McPherson K, Coulter A, Yeates D. The epidemiology of hysterectomy: findings in a large cohort study. Br J Obstet Gynaecol 1992;99:402-7.
14. Luoto R, Rutanen EM, Kaprio J. Five gynecologic diagnoses associated with hysterectomy—trends in incidence of hospitalizations in Finland, 1971-1986. Maturitas 1994;19:141-52.
15. Clarke A, Black N, Rowe P, Mott S, Howle K. Indications for and outcome of total abdominal hysterectomy for benign disease: a prospective cohort study. Br J Obstet Gynaecol 1995; 102:611-20.
16. Carlson KJ, Miller BA, Fowler FJ Jr. The Maine Women's Health Study, I: outcomes of hysterectomy. Obstet Gynecol 1994;83:556-65.
17. Schofield MJ, Bennett A, Redman S, Walters WA, Sanson-Fisher RW. Self-reported long-term outcomes of hysterectomy. Br J Obstet Gynaecol 1991;98:1129-36.

18. Amrika H, Evans T. Ten year review of hysterectomies: trends, indications and risks. Am J Obstet Gynecol 1979;134:431-7.
19. Dicker RC, Greenspan JR, Strauss LT, Cowart MR, Scally MJ, Peterson HB, et al. Complications of abdominal and vaginal hysterectomy among women of reproductive age in the United States. Am J Obstet Gynecol 1982;144:841-8.
20. Vercellini P, Parazzini F, Oldani S, Panazza S, Bramante T, Crosignani PG. Adenomyosis at hysterectomy: a study on frequency distribution and patient characteristics. Hum Reprod 1995;10:1160-2.
21. Longstreth GF, Preskill DB, Youkeles L. Irritable bowel syndrome in women having diagnostic laparoscopy or hysterectomy: relation to gynecologic features and outcome. Dig Dis Sci 1990;35:1285-90.
22. Walker EA, Gelfand AN, Gelfand MD, Green C, Katon WJ. Chronic pelvic pain and gynecological symptoms in women with irritable bowel syndrome. J Psychosom Obstet Gynecol 1996;17:39-46.
23. Ravnikar VA, Chen E. Hysterectomies: where are the indications? Obstet Gynecol Clin North Am 1994;21:405-11.
24. Hall RE, Cohen MM. Variations in hysterectomy rates in Ontario: does the indication matter? Can Med Assoc J 1994;151:1713-9.
25. Cramer SF, Patel A. Frequency of uterine leiomyomas. Am J Clin Pathol 1990;94:455-8.
26. Westphalen JB, Fraser S, Rea EE, Coulthard AC, Ng KH, Walters WA. Medical audit of hysterectomy in the Hunter area of New South Wales. Aust Clin Rev 1992;12:125-9.
27. Luoto R, Kaprio J, Keskimaki I, Pohjanlahti JP, Rutanen EM. Incidence, causes and surgical methods for hysterectomy in Finland, 1987-1989. Int J Epidemiol 1994;23:348-58.
28. Gitsch G, Berger E, Tatra G. Trends in thirty years of vaginal hysterectomy. Surg Gynecol Obstet 1991;172:207-10.
29. Goldhaber MK, Armstrong MA, Golditch IM, Sheehe PR, Petitti DB, Friedman GD. Long-term risk of hysterectomy among 80,007 sterilized and comparison women at Kaiser Permanente, 1971-1987. Am J Epidemiol 1994;138:508-21.
30. Rulin MC, Davidson AR, Phillibert SG, Graves WL, Cushman LF. Long-term effect of tubal sterilization on menstrual indices and pelvic pain. Obstet Gynecol 1993;82:118-21.
31. Stock RJ. Sequelae of tubal ligation: an analysis of 75 consecutive hysterectomies. South Med J 1984;77:1255-60.
32. Settnes A, Jorgensen T, Lange AP. Hysterectomy in Danish women: weight-related factors, psychologic factors, and life-style variables. Obstet Gynecol 1996;88:99-105.
33. Dennerstein L, Shelley J, Smith AM, Ryan M. Hysterectomy experience among mid-aged Australian women. Med J Aust 1994;161:311-3.
34. O'Connor VM, Del Mar CB, Sheehan M, Siskind V, Fox-Young S, Cragg C. Do psycho-social factors contribute more to symptom reporting by middle-aged women than hormonal status? Maturitas 1995;20:63-9.
35. Schofield MJ, Hennrikus DJ, Redman S, Sanson-Fisher RW. Prevalence and characteristics of women who have had a hysterectomy in a community survey. Aust N Z J Obstet Gynaecol 1991;31:153-8.
36. Baker LA, Treloar SA, Reynolds C, Heath A, Martin NG. Genetics of educational attainment in Australian twins: sex differences and secular changes. Behav Genet 1996;26:89-102.
37. Treloar SA, Martin NG. Age at menarche as a fitness trait: nonadditive genetic variance detected in a large twin sample. Am J Hum Genet 1990;47:137-48.