Adoption of Liquid-Based Cervical Cancer Screening Tests by Family Physicians and Gynecologists

Karen M. Rappaport, Christopher B. Forrest, and Neil A. Holtzman

Objective. To examine reasons for the adoption of liquid-based cervical cancer screening tests.

Data Sources/Study Setting. A mailed survey of 250 family physicians and 250 gynecologists in Maryland in 2000. Additional data were obtained from the AMA Master File of Physicians.

Study Design. Key outcome variables in this cross-sectional survey were *early adoption* of a liquid-based test by the end of 1997 and *overall adoption* by the time of the survey. Adoption was viewed in terms of a supply and demand theoretical framework with marketing influencing physician and patient demand as well as supply by insurance companies and laboratories.

Data Collection. Random samples of family physicians and gynecologists were selected from the AMA Master File of Physicians. The overall response rate was 61.9 percent.

Principal Findings. By 2000, 96 percent of gynecologists and 75 percent of family physicians in Maryland were using liquid-based cervical cancer screening tests, most commonly the ThinPrep[®] Pap Test[™]. Gynecologists were more likely than family physicians to have been early adopters (34 percent versus 5 percent, $p < .01$). Part of this variation in adoption was due to aggressive marketing to gynecologists, who were more likely than family physicians to receive information in the mail from the test manufacturer (89 percent versus 56 percent, $p < .01$) and to have been informed by the manufacturer that a patient had inquired about physicians' use of the test (22 percent versus 8 percent, $p < .01$).

Conclusions. The rapid diffusion of liquid-based cervical cancer screening tests occurred despite general agreement that the Pap smear has been one of the most successful cancer prevention interventions ever. Commercial marketing campaigns appear to contribute to the more rapid rate of diffusion of technology among specialists compared with generalists.

Key Words. Cervical cancer screening tests, ThinPrep, adoption, family physicians, gynecologists, medical decision making

The FDA approved the ThinPrep[®] Pap Test[™], a liquid-based cervical cancer screening test, in 1996 (Johannes 1998) (Cytoc Corporation 2001). Ever since,

the ThinPrep Pap test has been rapidly replacing the conventional Pap smear, even though it is about twice as costly as conventional Pap smears (Johannes 1998; Rubin 2002). According to the manufacturer, the Cytoc Corporation of Boxborough, Massachusetts, the test is now used in lieu of a conventional Pap smear in the United States for approximately two-thirds of cervical cancer screenings, a proportion that keeps increasing (Rubin 2002).

Although liquid tests are more effective at detecting precancerous changes and are associated with fewer numbers of ambiguous diagnoses than conventional Pap smears, most of the improvement in test accuracy is in the detection of low-grade lesions that often regress spontaneously (Brown and Garber 1999). Liquid-based technologies have not been shown to be superior to conventional Pap smears at detecting frank cancer and have not been associated with lower mortality from cervical cancer compared with Pap smears. Screening with conventional Pap smears once every three years between the ages of 20 and 75 increases the average woman's life expectancy by about 96 days (Eddy 1990). According to Brown and Garber (1999), annual screening with the ThinPrep Pap test would prolong the average woman's life approximately an additional six hours over annual screening with conventional Pap smears. In triennial screening programs, use of the ThinPrep Pap test instead of conventional smears would prolong the average woman's life about 19 hours (Brown and Garber 1999).

The lower rate of false positive cervical cancer screening tests is one reason for the rapid diffusion of the liquid-based tests, but other factors may also explain their rapid emergence in medical practice. The Cytoc Corporation, the makers of the ThinPrep[®] Pap Test[™] test (the most commonly used liquid test), actively marketed it to physicians and the general public. The company also encouraged insurance companies to promote

Dr. Rappaport was supported by a NRSA training grant (T32 HS00029) from the Agency for Healthcare research and Quality. Dr. Forrest was funded in part by an Independent Scientist Award from the Agency for Healthcare Research and Quality (K02 HS00003). Funds for physician financial incentives, used to enhance response rate, were obtained from an award made by the Johns Hopkins Bloomberg School of Public Health to Dr. Rappaport.

Address correspondence to Christopher B. Forrest, M.D., Ph.D., Associate Professor, Departments of Health Policy and Management and Pediatrics, Johns Hopkins Medical Institutions, 624 North Broadway, Room 689, Baltimore, MD 21205. Karen M. Rappaport, is an M.D., Ph.D. Neil A. Holtzman, M.D., M.P.H., is Professor Emeritus, Departments of Pediatrics, Epidemiology, and Health Policy and Management, Johns Hopkins Medical Institutions, Genetics and Public Policy Studies, Baltimore.

themselves to women by including information about their coverage of ThinPrep in advertising campaigns (Johannes 1998).

Articles concerning how physicians learn about new pharmaceutical agents began to appear in the medical literature in the 1950s (Peay and Peay 1994). In recent years, articles have focused on the influences of marketing to physicians on prescription behavior (Avorn, Chen, and Hartley 1982; Manning and Denson 1980) as well as the effect of marketing prescription drugs to the public (Bell, Kravitz, and Wilkes 1999; Wilkes, Bell, and Kravitz 2000; Avorn and Solomon 2000). However, little attention has been given to marketing of laboratory tests used in office-based practice. There is scant information on how office-based physicians choose new diagnostic tests. This paper examines adoption of liquid-based cervical cancer screening tests among family physicians and gynecologists in Maryland. We hypothesized that the efforts of Cytoc Corporation to market the ThinPrep Pap test would be an important determinant of its early adoption by physicians. Additionally, we examined the effects of physician specialty, patient sociodemographics, practice factors, and financial constraints on laboratory decision making on the adoption of liquid-based cervical cancer screening tests.

METHODS

Study Population

The American Medical Association Master File of Physicians was used to create a sampling frame of Maryland family physicians and gynecologists. The selection criteria resulted in a total of 2,025 physicians (1,079 family physicians and 946 gynecologists). Physicians who did not graduate from medical school between 1950 and 1989 were excluded in an effort to restrict the sample to physicians still in practice who had had experience with conventional Pap smears before liquid-based tests were available. Physicians known to be working in federal facilities were also excluded. We randomly selected 250 physicians from each of the two specialty groups using a random number generator. Assuming a 50 percent response rate, this sample size would detect a difference of at least 20 percent in the adoption rates for these groups with a power of .85 (two-tailed alpha of 0.05).

Between July and October 2000, the name of each physician was searched on the web site of the American Medical Association (American Medical Association 2001) and the Yahoo search engine on the Internet for a current Maryland address and telephone number (Yahoo yellow pages 2001).

The medical offices of the physicians were then contacted by telephone to determine if the physician offered routine gynecologic care with screening for cervical cancer. The office staffs of physicians chosen for the study were asked to verify addresses and provide fax numbers. In order to obtain basic information about all physicians in the study, including those who did not eventually respond to the questionnaire, the office staffs were also asked if the physicians use a liquid-based cervical cancer screening test, either the ThinPrep Pap test or AutoCyte (a less commonly used test), conventional Pap smears, or both.

The majority of physicians who were excluded (56.0 percent of the 2,025 physicians considered for the sample) from the study sample before the telephone screen either did not graduate from medical school in the time frame of interest (as determined by the master file of physicians) or could not be located at a current address in Maryland. A minority of physicians was excluded because they were inactive or retired, or because their primary specialty was neither obstetrics and gynecology nor family medicine. In some cases, this information was obtained from the master file, and in other cases, the information was obtained from the yellow pages or during the telephone screen. Physicians whose office staffs indicated that they did not perform routine pelvic examinations were dropped from the study sample ($n = 57$ of 2,025 physicians in sample frame). Less than 1.0 percent of physicians or their office staffs refused to participate at the time of the telephone screen, and 5.1 percent of physician offices were closed each of three times that telephone calls were made. The reasons for exclusion of physicians from the study were similar for both gynecologists and family physicians except that family physicians were slightly more likely to be excluded from the study for not providing routine gynecologic care (4.2 percent of family physicians versus 1.3 percent of gynecologists).

The final sample of 500 physicians was composed of 23.2 percent of all considered family physicians and 26.4 percent of all considered gynecologists, representing 99.1 percent and 74.1 percent of all physicians listed as family physicians and obstetrician gynecologists in Maryland respectively.

Questionnaire Development

The survey instrument was a self-administered questionnaire with 14 questions and a total of 51 items. Adoption of laboratory tests was viewed in terms of a supply and demand theoretical framework (Rice 1998). Physician and patient factors were conceptualized as determinants of demand while

laboratory availability, practice setting, and insurance mix were conceptualized as determinants of supply. The physician factors that potentially influence demand include such variables as specialty, gender, innovativeness, practice location, and attitudes of physicians and their opinion leaders toward Pap smears and new cervical cancer screening technologies. The patient factors that could create demand for a new laboratory test include the sociodemographic mix of the population and patients' risk factors for disease.

Marketing campaigns influence both demand by physicians and patients as well as supply by insurance companies and laboratories. The marketing strategies analyzed in this study included direct targeting of physicians using mailings of promotional materials and journal advertisements. Respondents were also asked if they had found information about the ThinPrep Pap test on the World Wide Web, been personally encouraged by a pathologist or technologist to adopt the test, and received information in the mail from laboratories about it. Physicians were not asked if they had been visited in their offices by representatives from Cytec. They also were not asked if they had been offered free samples reminiscent of the way doctors are often given free samples of pharmaceuticals for their patients, because the test must be processed by a laboratory. Marketing of the ThinPrep Pap test to patients was measured indirectly by asking physicians if patients had informed them that they had seen advertisements for ThinPrep. The Cytec Corporation invites patients to look on their web site to see if their physicians use the test and offers to contact physicians who are not listed (Cytec Corporation 2001). Respondents were asked in the questionnaire about being contacted by Cytec for this reason.

Multiple sources were used to identify variables that influence adoption of liquid-based cervical cancer screening tests. In September 1998, we queried family physicians participating on the *Ambulatory Sentinel Practice Network* (a national primary care practice-based research network) e-mail LISTSERV about their reasons for adopting or not adopting the ThinPrep Pap test. Three gynecologists and a clinical pathologist were also interviewed. The diversity of responses suggested the importance of such factors as laboratory adoption, insurance coverage, marketing, and personal attitudes in determining adoption by physicians of a new laboratory test. Journal and newspaper articles and books on both cervical cancer screening and the diffusion of medical technology were reviewed (Eddy 1990; Johannes 1998; Rogers 1995). The investigators reviewed Cytec Corporation advertising to develop *attitude* variables concerning the relative merits of liquid-based tests and conventional Pap smears (Cytec Corporation 2001).

With the exception of physician characteristics, namely gender, year of graduation from medical school, country of medical school graduation, and board certification status, which were obtained from the AMA master file of physicians or the web site of the American Medical Association (AMA 2001), all data were elicited in the study instrument.

Procedures for Survey Administration

All procedures were approved by the Institutional Review Board of the Johns Hopkins Bloomberg School of Public Health. Questionnaires were mailed to physicians. A personalized letter from the principal investigator, a letter from the president of the Maryland Society of Obstetricians and Gynecologists, a self-addressed and stamped return envelope, and a \$5.00 check accompanied each questionnaire. Physicians were told that it would take about 10 minutes to complete the questionnaire and were not asked to verify their responses by checking records. Physicians received materials during a two-week period in October 2000. Reminder post cards to physicians who had not yet responded were mailed two weeks after the posting of the last questionnaires. Questionnaires were faxed to nonresponding physicians for whom fax numbers had been obtained during the initial telephone screen. Second mailings with self-addressed return envelopes were sent to remaining nonresponders. Follow-up of nonresponders ended in mid-December 2000, and returned questionnaires were accepted through January 2001.

Variables

Dependent Variables. According to diffusion theory, late adopters often start to use a new technology only after the realization that their colleagues have successfully adopted and opinion leaders advocate adoption (Rogers 1995). To analyze the factors associated with early as well as overall adoption of new technology and to moderate potential recall bias regarding the specific year of adoption, three adoption outcome variables were created. First, physicians who reported adoption of either ThinPrep or AutoCyte were categorized as adopters. Only six physicians, four of whom reported using the ThinPrep Pap test, were adopters of AutoCyte. Second, early adoption was defined to include affirmative responses from before or during 1997, with all other responses collapsed into a category of late/never adoption. For physicians who had adopted both liquid tests, the earliest year of adoption for either was used. Third, a less stringent early adoption variable, which used adoption by

the end of 1998, was created to analyze the family physician data only, because adoption among family physicians was rare before 1998 and did not begin to escalate rapidly until 1999.

Independent Variables. Questions on physician attitudes used a five-category response format: strongly agree, agree, unsure, disagree, and strongly disagree. The variables “strongly agree” and “agree” were collapsed, as were “strongly disagree” and “disagree” with the unsure responses being counted as disagree. We felt that it was more important to distinguish those responders who clearly agreed with a given statement, rather than those who clearly disagreed. For most questions on physician attitudes, less than 5 percent of physicians “strongly disagreed” with the given statement. Questions that asked respondents about the frequency of being targeted by various marketing tactics were recoded never/ever, regardless of the frequency recorded.

To obtain measures of innovativeness in the use of other new technologies of “low per unit cost” we added questions about the uses of ciprofloxacin for resistant urinary tract infections, diflucan for treatment of vaginal candidiasis, and aldara for treatment of vaginal warts. These pharmaceuticals were chosen because both gynecologists and family physicians commonly treat women with urinary tract infections, vaginal candidiasis, and vaginal warts. The variables concerning ciprofloxacin and diflucan were recoded to distinguish those physicians who prescribe the drugs most of the time. The variable for use of aldara for the treatment of genital warts was recoded to reflect those physicians who never prescribe the drug versus those who prescribe the drug for occasional or the majority of patients. A pharmaceutical adoption index that distinguishes physicians who never prescribe aldara or do not usually prescribe ciprofloxacin or diflucan when appropriate was created as a composite measure of innovativeness. The year of medical school graduation was converted to a dichotomous variable—1970s/1980s versus 1950s/1960s. Physician practice type was dichotomized as single specialty group/solo practices versus other (i.e., physicians who work primarily in clinics, academic medical centers, HMOs, and multispecialty groups).

DATA ANALYSIS

Independent variables were grouped into physician characteristics, physician attitudes toward conventional Pap smears and liquid-based tests, innovative-

ness of physicians, patient population characteristics, laboratory variables, and marketing factors. To determine if there were differences in exposure to marketing strategies between gynecologists and family physicians, each marketing variable was tabulated against physician specialty. Marketing as well as all other variables in the study were tabulated against each of the three adoption variables (overall adoption and two early adoption variables defined in different ways as described above), and odds ratios were calculated. Because adoption was relatively common and odds ratios for common outcomes (> 10 percent) overestimate effect sizes, we converted odds ratios and 95 percent confidence intervals into relative risk estimates according to the method proposed by Zhang and Yu (1998) for tabulations with p -values less than or equal to .08.

Only variables with p -values $< .08$ were entered into stepwise logistic regression analyses with forward selection. Variables pertaining to physician characteristics, which included the most significant variable of physician specialty, were entered first, followed by marketing variables, physician attitudes toward conventional Pap smears and liquid-based tests, patient characteristics, and, lastly, innovativeness variables. The order in which the groups of variables were entered was determined primarily by the significance of the cross-tabulations with outcome variables. None of the variables regarding laboratory characteristics, such as one concerning whether the laboratory that the physician uses processes liquid-based cervical cancer screening tests, were significantly related to adoption and were, therefore, not entered into regression equations. If the p -value for the likelihood ratio test was less than .12 (a cut-off chosen to limit the possibility that an important variable would be excluded from the model), the variable was retained in the model (Hosmer and Lemeshow 2000). Each omitted variable was then analyzed individually to determine if it was significant in the final model, but none were significant. Interaction terms between physician specialty and each variable in the final model were analyzed in order to determine if variables had different effects on adoption depending on the physician specialty; none were significant.

The combined dataset of gynecologists and family physicians was analyzed using both the early adoption and overall adoption outcome variables. Additional subanalyses were done separately to analyze early adoption among the gynecologist and family physician samples, primarily so that the family physician sample could be analyzed using a more realistic early adoption variable that reflects later adoption of liquid tests by family physicians. The c-statistic, the area under the receiver operator characteristic

curve (a plot of sensitivity versus 1-specificity of each regression equation), was obtained for each model to obtain comparative measures of explanatory power. Goodness-of-fit tests (Pearson and Hosmer-Lemeshow) and regression diagnostics, including analyses of residuals, leverage values, influence, and examination of outlying values, revealed good fit for all models.

RESULTS

Of the 500 physicians who were mailed questionnaires, three gynecologists and six family physicians were eliminated from the study because questionnaires were returned due to incorrect addresses or because the physicians responded that they do not screen for cervical cancer. The overall response rate of the remaining 491 physicians was 61.9 percent. Response rates did not differ significantly by physician specialty, gender, decade of graduation, location of medical school, or board certification. However, 66.0 percent of physicians whose office staff reported during the telephone screen that they used liquid-based cervical cancer screening tests responded to the survey compared with only 48.6 percent of physicians whose office staff reported that they do not ($p < .05$). Among responding physicians whose office staffs said that the physicians had adopted liquid tests, 98 percent indicated that they had adopted. On the other hand, among responding physicians whose office staffs said that the physicians had *not* adopted liquid tests, 35.3 percent indicated that in fact they had adopted it. The physician's response, not the office staff's, was used to classify the physician.

The diffusion curves of liquid-based cervical cancer screening tests for the combined and family physician data (see Figure 1) are S-shaped. Adoption among family physicians lagged behind adoption among gynecologists by approximately two years. By the end of 2000, adoption among family physicians had begun to decelerate but had not yet quite leveled. Adoption of liquid tests among gynecologists, in contrast, peaked rapidly without an initial slow rise and then leveled off in 1999 and 2000 as most of the few remaining nonadopters adopted.

Tabulations of physician specialty by the marketing variables showed that gynecologists were more likely than family physicians to report exposure to marketing efforts including exposure to Cytoc Corporation's advertising, efforts by pathologists or technologists to encourage clinicians to use ThinPrep, and patient requests (Table 1). However, gynecologists were not significantly more likely than family physicians to receive information from

Figure 1: Diffusion Curve of Liquid-Based Cervical Cancer Screening Tests

The typical S-shaped diffusion curves are seen in the combined set and family physician subset to rise slowly at first following approval of ThinPrep by the Food and Drug Administration in late 1996, escalate to a maximum until half of the physicians have adopted, and then increase at a slower rate as remaining physicians adopt. Adoption among gynecologists, in contrast, peaked rapidly without an initial slow rise and then leveled off in 1999 and 2000 as most of the few remaining nonadopters finally adopted.

laboratories about ThinPrep. Gynecologists also reported more frequent encounters with marketing efforts than did family physicians.

Although early adopters were more likely to practice in single specialty groups or in solo practice (Table 2), adoption by any survey respondent by the end of 2000 was not associated with practice setting (Table 3). The gender of the physician was not associated with adoption status except that in the family physician subset of data, female physicians were significantly more likely to adopt liquid tests by the end of 1998 than their male colleagues (not shown in the cross-tabulation tables). Early and overall adoption were both associated with exposure to marketing campaigns.

Table 1: Differences in Exposure to Marketing by Physician Specialty

<i>Marketing Strategy</i>	<i>Gynecologists</i>	<i>Family Physicians</i>	<i>P-Value</i>
Received information in the mail from the manufacturer about ThinPrep [®]	135/151 (89.4%)	79/142 (55.6%)	<.01
Received information in the mail from laboratories about ThinPrep [®]	99/151 (65.6%)	83/142 (58.5%)	.21
Found information on the World Wide Web about ThinPrep [®]	37/145 (25.5%)	14/140 (10.0%)	<.01
Been personally encouraged by either a pathologist or technologist to use ThinPrep [®]	46/148 (31.2%)	23/142 (16.2%)	<.01
Been informed by the manufacturer of ThinPrep [®] that a patient had inquired about your use of the test	33/149 (22.2%)	11/142 (7.8%)	<.01
Read advertisements for ThinPrep [®] in professional journals	136/150 (90.7%)	74/142 (52.1%)	<.01
Had patients inform you that they had either read or heard about ThinPrep [®] or seen advertisements for it	142/149 (95.3%)	87/142 (61.3%)	<.01

A logistic regression model of early adoption using the combined (both gynecologists and family physicians) dataset without inclusion of the specialty variable is shown in Table 4 (column 1). The explanatory power of the model increased minimally, and the effect sizes of the marketing variables decreased when the specialty variable was included in the analysis (column 2). Similarly, in the specialty-specific logistic regression analyses of early adoption (columns 3 and 4 of Table 4), marketing factors lose their impact and are no longer significant. Having few patients who could not afford to pay for liquid-tests out-of-pocket and the innovativeness of the physician are also important determinants of early adoption.

The logistic regression models of the combined and family physician datasets using overall adoption outcome variables are seen in Table 5. Virtually all physicians who agreed with the statement that conventional Pap smears are outdated had adopted liquid-based tests. As a result, this variable was dropped from the regression equations. In the combined data-set, adopters were also more likely than nonadopters to agree that use of conventional Pap smears poses problems with high numbers of ambiguous test results, but this variable did not distinguish between family physicians who have and have not adopted the technology. Patient awareness of the ThinPrep Pap test is an important determinant of overall adoption for both specialties.

Table 2: Early Adoption (by or during 1997) by Physicians of Liquid-Based Tests: Significant Associations with Patient, Physician, and Marketing Characteristics

		<i>Total Number</i>	<i>% Early Adopters</i>	<i>P-Value</i>
<i>Physician Characteristics</i>				
Physician specialty	Gynecology	158	33.5	< .01
	Family Practice	146	4.8	
Practice setting*	Single specialty group or solo	255	22.8	.01
	Other	44	4.6	
<i>Physician Attitudes toward Conventional Pap Smears and Liquid-Based Tests</i>				
Liquid-based tests are a notable advance in women's reproductive health care	Agree	208	22.6	.06
	Disagree	86	12.8	
Conventional Pap smears are outdated	Agree	72	31.9	< .01
	Disagree	223	15.7	
Physicians who do not offer liquid-based tests risk incurring lawsuits in the future	Agree	67	29.9	.02
	Disagree	227	16.7	
<i>Innovativeness of Physicians</i>				
Pharmaceutical adoption index [†]	At least 1 of 3 pharmaceuticals	244	25.5	.01
	No pharmaceuticals	56	7.1	
Physician respondent reported using Aldara during the year prior to the survey	Yes	174	24.1	.02
	No	126	13.5	
Self-reported innovative user of new laboratory tests	Yes	163	27.0	< .01
	No	127	11.0	
<i>Patient Population Characteristics</i>				
Access to liquid-based tests was at first limited by presence of patients who could not afford to pay out-of-pocket for tests	Important limiting factor	202	16.8	.05
	Not important limiting factor	89	27.0	
Access to liquid-based tests currently limited by presence of patients who cannot afford to pay out-of-pocket for tests	Important limiting factor	171	14.0	< .01
	Not important limiting factor	116	29.3	

continued

Table 2: *Continued*

		<i>Total Number</i>	<i>% Early Adopters</i>	<i>P-Value</i>
<i>Marketing Factors</i>				
During the past year, physician respondents read advertisements for ThinPrep	Yes	210	25.7	<.01
	No	82	4.9	
During the past year, physician respondents reported that patients mentioned ThinPrep	Yes	229	23.6	<.01
	No	62	6.4	

*None of the seven university-based physicians (three gynecologists and four family physicians) in the study were early adopters of a liquid-based cervical cancer screening test. Along with doctors who practice primarily in clinic settings, multigroup practices, or HMOs, the practice setting of university-based physicians was categorized as "other."

†During the year prior to the survey, physician respondent used, when indicated, at least one of the following: aldara, at least some of the time; ciprofloxacin for resistant UTIs, most of the time; or diflucan, most of the time.

DISCUSSION

Within four years of its approval by the FDA, 96 percent of gynecologists and 75 percent of family physicians in the state of Maryland were using liquid-based cervical cancer screening tests, almost exclusively the ThinPrep Pap test. This rapid rate of diffusion occurred despite near universal agreement on the part of most physicians and researchers as reported in the medical literature that use of conventional Pap smears over the last 40 years has been one of the most successful cancer prevention interventions ever undertaken (Johannes 1998; Brown and Garber 1999). Comparable evidence regarding the effectiveness of the ThinPrep Pap test for further reducing rates of cervical cancer mortality is lacking.

Our findings suggest that physician specialty was a strong determinant of adoption of ThinPrep. Other research has found that specialists become more aware of diagnostic (Harrold, Field, and Gurwitz 1999; Rosser 1996) and therapeutic (Hlatky et al. 1988; Diette et al. 2001) advances faster than their generalist counterparts; however, little attention has been given to the role that marketing might play in these specialty differences. Our study suggests that aggressive marketing by the Cytoc Corporation Company, the makers of the ThinPrep® Pap Test™, was preferentially targeted at gynecologists. According to survey results, gynecologists were much more likely than family physicians

Table 3: Adoption (by or during 2000) by Physicians of Liquid-Based Tests: Significant Associations with Patient, Physician, and Marketing Characteristics

		<i>Total Number</i>	<i>% Adopters</i>	<i>P-Value</i>
<i>Physician Characteristics</i>				
Physician specialty	Gynecology	158	95.6	< .01
	Family Practice	146	74.7	
Decade of graduation from medical school	1970s or 1980s	223	87.9	.05
	1950s or 1960s	81	79.0	
<i>Physician Attitudes toward Conventional Pap Smears and Liquid-Based Tests</i>				
Liquid-based tests are a notable advance in women's reproductive health care	Agree	208	94.7	< .01
	Disagree	86	65.1	
Conventional Pap smears are outdated	Agree	72	98.6	< .01
	Disagree	223	81.6	
Physicians who do not offer liquid-based tests risk incurring lawsuits in the future	Agree	67	100.0	< .01
	Disagree	227	81.5	
The large number of atypia diagnoses associated with conventional Pap smears is a big problem	Agree	189	93.1	< .01
	Disagree	105	72.4	
<i>Patient Population Characteristics</i>				
Access to liquid tests was limited at first by the presence of patients who lacked insurance coverage for the test	Important limiting factor	249	88.4	< .01
	Not important limiting factor	44	70.5	
<i>Marketing Factors</i>				
Physician respondents reported that during the year prior to the survey, patients mentioned ThinPrep®	Yes	229	91.7	< .01
	No	62	64.5	
Physician respondents reported that during the year prior to the survey, they had been encouraged to use ThinPrep® by pathologists	Yes	69	97.1	< .01
	No	221	82.4	

to report having been contacted by the Cytyc Corporation during the year prior to the survey and to have had patients inform them that they had either read or heard about the ThinPrep Pap test. The Cytyc Corporation web site encourages women to contact their physicians to find out about the use of the ThinPrep Pap test in their physicians' practices, and to contact the company if their physicians do not use it (Cytyc Corporation 2001). The company also posts lists of physicians who have adopted the ThinPrep Pap test.

Table 4: Determinants of Early Adoption by Physicians of Liquid-Based Tests: Logistic Regression Analyses[†]

<i>Variables</i>	<i>Estimated Relative Risk (95% Confidence Interval)</i>			
	<i>Combined Dataset (Specialty Variable Omitted) (1)</i>	<i>Combined Data Set (Specialty Variable Included) (2)</i>	<i>Gynecologist Subset of Data (3)</i>	<i>Family Physician Subset of Data** (4)</i>
Physician specialty				
Gynecologists		7.63 (3.74–12.60)		
Family Physicians		Referent		
Practice setting*				
Single specialty group/solo	4.17 (1.09–11.25)			
Other	Referent			
During the past year, physician respondent has read advertisements for ThinPrep [®] in medical journals	4.16 (1.58–8.94)	1.12 (.94–1.19)		
Yes	Referent	Referent		
No				
During the past year, patients have told physician that they have heard of ThinPrep [®]	2.75 (1.00–6.24)			
Yes	Referent			
No				
Physician agrees with statement that conventional Pap smears are outdated	1.76 (1.00–2.79)	1.59 (.84–2.69)		
Agree	Referent	Referent		
Does not agree			1.73 (.91–2.70)	4.47 (1.61–8.85)
Physician agrees with statement that liquid-based tests are a major advance			Referent	Referent
Access to liquid-based tests	.43 (.24–.75)	.39 (.20–.71)	.41 (.21–.74)	
Yes	Referent	Referent	Referent	
currently limited by presence of patients who cannot afford to pay out-of-pocket for tests				
No				

continued

Table 4: Continued

<i>Variables</i>	<i>Estimated Relative Risk (95% Confidence Interval)</i>			
	<i>Combined Dataset (Specialty Variable Omitted) (1)</i>	<i>Combined Data Set (Specialty Variable Included) (2)</i>	<i>Gynecologist Subset of Data (3)</i>	<i>Family Physician Subset of Data** (4)</i>
Physician respondent categorizes himself/herself as an early user of new laboratory tests in comparison with other physicians in his or her specialty	Yes 2.50 (1.40–4.02) Referent	Yes 2.73 (1.49–4.42) Referent	2.45 (1.43–3.58) Referent	3.24 (1.58–5.30) Referent
	No			
Pharmaceutical adoption index	At least one of three		2.40 (.92–4.56) Referent	
Number of observations	274	275	139	137

[†]Significant variables that appear in Table 2 were entered into regression equations. Boxes in the table are left blank if the variable was not significant in the logistic regression equation using the outcome variable in question.

*All gynecologists who were early adopters practice in single specialty group or solo practice settings.

**Early adoption among family physicians in the family physician subset of data was analyzed by using an early adoption variable of adoption by the end of 1998, rather than 1997, as was used in the analyses of the combined datasets and the gynecologists subset of data.

The c-statistics (see text for explanation) were .81, .86, .76, and .74 from left to right for models, respectively.

Table 5: Determinants of Overall Adoption by Physicians of Liquid-Based Tests: Logistic Regression Analyses[†]

<i>Variables</i>		<i>Estimated Relative Risk (95% Confidence Interval)</i>	
		<i>Combined Dataset (1)</i>	<i>Family Physician Subset of Data (2)</i>
Physician specialty	Gynecologists	1.27	
	Family Physicians	1.16 1.32	Referent
Physician agrees with statement that liquid-based tests are a major advance	Agree	1.47	2.42
	Does not agree	1.37 1.51	2.17 2.50
During the past year, patients have told physician that they have heard of ThinPrep [®]	Yes	Referent	Referent
	No	1.38	1.53
During the past year, physician has been encouraged by a pathologist to adopt ThinPrep [®]	Yes	1.17 1.48	1.28 1.62
	No	Referent	Referent
Physician agrees with statement that conventional Pap smears have problems	Yes	1.15	1.34
	Does not agree	.95 1.20	.94 1.39
Decade physician graduated from medical school	Agree	Referent	Referent
	Does not agree	1.22	
	1970s & 1980s	1.03 1.31	
	1950s & 1960s	Referent	Referent
Number of observations		1.07	1.64
		.98 1.14	1.21 1.80
		287	140

[†]Significant variables that appear in Table 3 were entered into regression equations. The c-statistics (see text for explanation) were .90 for both models.

The medical literature and the lay press have highlighted the economic disparities associated with aggressive direct-to-consumer marketing of high technology screening tests such as electron-beam-computed tomography to screen for coronary artery disease and low-dose spiral tomography to screen for cancer that are not covered by most insurance plans (Lee and Brennan 2002; Brody 2002). Yet, the same economic disparities also exist with the use of ThinPrep. Our survey showed that physicians who were early adopters of liquid tests were significantly more likely than others to record that they did not feel constrained in their adoption by poor patients who could not afford to pay out-of-pocket for the test. The ThinPrep Pap test detects more cases of low-grade lesions that often resolve spontaneously, potentially leading to more colposcopy and biopsy procedures than do conventional Pap smears. Costly work-ups, whether they are a result of increased sensitivity of ThinPrep to

reveal low-grade lesions or a high-technology screening test, are usually covered by conventional medical insurance. This increased follow-up drives up the cost of medical care even for patients who cannot afford to avail themselves of the technology that necessitated them (Lee and Brennan 2002; Brody 2002).

This study's findings also suggest that among family physicians who provide routine gynecologic care to their female patients, female physicians might be more likely to adopt new technology related to reproductive health care before male physicians. This result is consistent with other work demonstrating that primary care physicians who are older and male are more likely to use PSA testing to screen for prostate cancer (Edlefsen et al. 1999; Lawson et al. 1998). However, once the accelerated phase of the diffusion of a new technology is complete, gender is no longer a determining factor in adoption. The study shows that some physicians are inherently more innovative than others and even think of themselves as innovators in comparison with other physicians in their specialty.

Several caveats should be considered in interpreting the results of this study. This survey was fielded before the publication in 2002 of the comprehensive evidence-based guidelines on using DNA-based HPV tests in conjunction with liquid-based cervical cancer screening tests to follow-up on some women with atypical test screening results (Wright et al. 2001). In addition, the office staffs of respondents to the survey were more likely to have indicated physician adoption of liquid-based cervical cancer screening tests during the telephone screening than were the office staffs of nonresponding physicians. This difference in response rate may have inflated our estimate of overall adoption rates of the ThinPrep Pap test. Recall bias should also be considered as another potential limitation. If some early adopters underestimated how many years ago they had adopted liquid-based cervical cancer screening tests, they would be misclassified as late adopters, thereby biasing results toward the null.

Another limitation of the study was that it investigated adoption of specific pharmacological agents rather than various agents that might be used to treat the disease in question. A true index of adoption could not be developed, because most of the respondents prescribe ciprofloxacin for resistant urinary tract infections and diflucan for treatment of vaginal candidiasis at least some of the time. The data obtained on the use of ciprofloxacin was limited by the fact that it could not be determined if physicians who did not usually use the drug were instead using an older drug or a newer alternative, or even if use was related to marketing or to the

application of evidence-based studies. However, a positive response to at least one of the variables comprising the index was clearly associated with early adoption of liquid-based cervical cancer screening tests.

The study did not consider the role of marketing on the part of manufacturers to laboratories in the diffusion of liquid-based cervical cancer screening tests. For overall adopters of liquid tests, there was a trend for adoption to be associated with physicians being encouraged by a pathologist to use the test. However, the determining factors that led the laboratories to adopt the technology were not identified in this study. The study also did not address the factors associated with adoption of laboratory tests by insurance companies. The extent to which managed care companies have adopted liquid tests in order to use their adoption as a marketing tool, and the extent to which they have been pressured by physicians and patients to make the technology available remains unknown (Johannes 1998).

Just as physicians have an array of pharmaceutical agents to choose from to treat a patient's condition, they sometimes have a choice between older, less accurate laboratory tests and new ones with incremental benefits. This study demonstrates that a new technology such as liquid-based cervical cancer screening tests with questionable benefits over conventional Pap smears when used in all patients indiscriminately can diffuse rapidly if conditions are favorable. The reduction in physician "hassle" associated with false positives in some patients is certainly a driving force behind widespread rapid adoption of the ThinPrep Pap test for many patients. Advocates of competition in health care assume that market forces will foster cost-effective choices. One implication of our study is that aggressive marketing may have the effect of less-cost-effective care if the agent being marketed is less cost-effective than the agent it is intended to replace. Research on the adoption of HPV-DNA typing and more research comparing various scenarios for optimal use of liquid-based cervical cancer tests are needed before this determination can be made for cervical cancer screening.

With aggressive direct-to-consumer marketing of high technology screening tests on the rise, the challenge will be to counter marketing with careful consideration of effectiveness in different patient populations. For physicians in specialty group and solo practices, who were the primary early adopters of liquid-based cervical cancer screening tests in this study, laboratory test ordering is restricted primarily by the ability and willingness of patients to pay. The challenge to policymakers is to maintain quality care while keeping costs manageable even as our technological capabilities expand (Rice 1998). As the private sector attempts to address perceived unmet

medical needs with new, costlier laboratory screening tests that have only incremental benefits over old ones, ways must be found to both protect the public's health and insure optimal use of limited financial resources.

ACKNOWLEDGEMENTS

This work benefited greatly from the assistance of the following individuals: Anthony J. Alberg, Ph.D., M.P.H. (Epidemiology and Oncology), Charles Flagle, Ph.D. (Health Policy and Management), Robert E. Miller M.D. (Pathology), Anne Skinner M.S.W. (Health Policy and Management), Donald Steinwachs Ph.D. (Health Policy and Management) from Johns Hopkins Medical Institutions, and Raymond Cox M.D., M.B.A. from Prince George's Hospital Center.

REFERENCES

- American Medical Association. 2001. "AMA Physician Select" [accessed July–October 2000]. Available at <http://www.ama-assn.org/aps/amahg.htm>.
- Avorn, J., M. Chen, and R. Hartley. 1982. "Scientific versus Commercial Sources of Influence on the Prescribing Behavior of Physicians." *American Journal of Medicine* 73 (1): 4–8.
- Avorn, J., and D. H. Solomon. 2000. "Cultural and Economic Factors That (Mis)Shape Antibiotic Use: The Nonpharmacologic Basis of Therapeutics." *Annals of Internal Medicine* 133 (2): 128–35.
- Bell, R. A., R. L. Kravitz, and M. S. Wilkes. 1999. "Direct-to-Consumer Prescription Drug Advertising and the Public." *Journal of General Internal Medicine* 14 (11): 705–6.
- Brody, J. E. 2002. "How Perils Can Await the 'Worried Wealthy'." *New York Times* Nov. 12, p. 7F.
- Brown, A. D., and A. M. Garber. 1999. "Cost-effectiveness of Three Methods to Enhance the Sensitivity of Papanicolaou Testing." *Journal of the American Medical Association* 281 (4): 347–53.
- Cytoc Corporation. 2003. "About Cytoc" [last accessed February 2003]. Available at <http://www.thinprep.com/>.
- Diette, G. B., E. A. Skinner, T. T. Nguyen, L. Markson, B. D. Clark, and A. W. Wu. 2001. "Comparison of Quality of Care by Specialist and Generalist Physicians as Usual Source of Asthma Care for Children." *Pediatrics* 108 (2): 432–7.
- Eddy, D. M. 1990. "Screening for Cervical Cancer." *Annals of Internal Medicine* 113 (3): 214–26.

- Edlefsen, K. L., M. T. Mandelson, M. W. McIntosh, M. R. Andersen, E. H. Wagner, and N. Urban. 1999. "Prostate-Specific Antigen for Prostate Cancer Screening." *American Journal of Preventive Medicine* 17 (1): 87-90.
- Harrold, L. R., T. S. Field, and J. H. Gurwitz. 1999. "Knowledge, Patterns of Care, and Outcomes of Care for Generalists and Specialists." *Journal of General Internal Medicine* 14 (8): 499-511.
- Hlatky, M. A., H. Cotugno, C. O'Connor, D. B. Mark, D. B. Pryor, and R. M. Califf. 1988. "Adoption of Thrombolytic Therapy in the Management of Acute Myocardial Infarction." *American Journal of Cardiology* 61 (8): 510-4.
- Hosmer, D. W., and S. Lemeshow. 2000. *Applied Logistic Regression*, 2d. New York: Wiley.
- Johannes, L. 1998. "Smear Campaign." *Wall Street Journal*, Aug 13, p.1.
- Lawson, D. A., E. J. Simoes, D. Sharp, T. Murayi, R. Hagan, R. C. Brownson, and J. Wilkerson. 1998. "Prostate Cancer Screening—A Physician Survey in Missouri." *Journal of Community Health* 23 (5): 347-58.
- Lee, T. H., and T. A. Brennan. 2002. "Direct-to-Consumer Marketing of High-Technology Screening Tests." *New England Journal of Medicine* 346 (7): 529-31.
- Manning, P. R., and T. A. Denson. 1980. "How Internists Learned about Cimetidine." *Annals of Internal Medicine* 92 (5): 690-2.
- Peay, M. Y., and E. R. Peay. 1994. "Innovation in High Risk Drug Therapy." *Social Science Medicine* 39 (1): 39-52.
- Rice, T. 1998. *The Economics of Health Reconsidered*. Chicago: Health Administration Press.
- Rogers, E. M. 1995. *Diffusion of Innovations*, 4th ed. New York: Free Press.
- Rosser, W. W. 1996. "Approach to Diagnosis by Primary Care Clinicians and Specialists: Is There a Difference?" *Journal of Family Practice* 42 (2): 139-44.
- Rubin, R. 2002. "Putting the Pap to the Test: New Versions Might Not Be Better at Preventing Deaths" [accessed February 2003]. *USA Today*, May 21. Available at <http://pqasb.pqarchiver.com/USAToday>.
- Wilkes, M. S., R. A. Bell, and R. L. Kravitz. 2000. "Direct-to-Consumer Prescription Drug Advertising: Trends, Impact, and Implications." *Health Affairs (Millwood)* 19 (2): 110-28.
- Yahoo yellow pages. 2002. "Yellow pages" [accessed in 2000]. Available at <http://yp.yahoo.com/>.
- Wright, T. C. Jr., J. T. Cox, L. S. Massad, L. B. Twiggs, and E. J. Wilkinson. 2001. "Consensus Guidelines for the Management of Women with Cervical Cytological Abnormalities." *Journal of the American Medical Association* 287 (16): 2120-9.
- Zhang, J., and K. F. Yu. 1998. "What's the Relative Risk?" *Journal of the American Medical Association* 280 (19): 1690-1.