Accuracy of Ovarian and Colon Cancer Risk Assessments by U.S. Physicians

Laura-Mae Baldwin, MD, MPH[1], Katrina F. Trivers, PhD, MSPH[2], C. Holly A. Andrilla, MS[1], Barbara Matthews, MBA[1], Jacqueline W. Miller, MD[2], Denise M. Lishner, MSW[1], and Barbara A. Goff, MD[3]

[1]Department of Family Medicine, University of Washington, Seattle, WA, USA; [2]Division of Cancer Prevention and Control, Centers for Disease Control and Prevention, Atlanta, GA, USA; [3]Department of Obstetrics and Gynecology, University of Washington, Seattle, WA, USA.

BACKGROUND: Studies have shown a mismatch between published cancer screening and genetic counseling referral recommendations and physician-reported screening and referral practices. Inaccurate cancer risk assessment is one potential cause of this mismatch.

OBJECTIVE: To assess U.S. physicians' ability to accurately determine a woman's colon and ovarian cancer risk level.

DESIGN, PARTICIPANTS: Cross-sectional survey of U.S. family physicians, general internists, and obstetrician-gynecologists. A twelve-page questionnaire with a vignette of a woman's annual examination included a question about the patient's level of colon and ovarian cancer risk. The final study sample included 1,555 physicians weighted to represent practicing U.S. physicians nationally.

MAIN MEASURE: Accuracy of physicians' ovarian and colon cancer risk assessments.

KEY RESULTS: Overall, most physicians accurately assessed women's risk of ovarian (57.0 %, CI 54.3, 59.6) and colon cancer (62.0 %, CI 59.4, 64.6). However, 27.1 % (CI 23.0, 31.6) of physicians overestimated the ovarian cancer risk among women at the same risk as the general population, and 65.1 % (CI 60.2, 69.7) underestimated ovarian cancer risk among women at much higher risk than the general population. Physicians overestimated colon more than ovarian cancer risk (38.0 %, CI 35.4, 40.6 vs. 27.1 %, CI 23.0, 31.6) for women at the same risk as the general population.

CONCLUSIONS: Physicians' misestimation of patient ovarian and colon cancer risk may put average risk patients in jeopardy of unnecessary screening and higher risk patients in jeopardy of missed opportunities for prevention or early detection of cancers.

Electronic supplementary material *The online version of this article (doi:10.1007/s11606-014-2768-2) contains supplementary material, which is available to authorized users.*

Received June 19, 2013
Revised November 20, 2013
Accepted December 11, 2013
Published online February 12, 2014

KEY WORDS: cancer; quality of care; risk estimation.
J Gen Intern Med 29(5):741–9
DOI: 10.1007/s11606-014-2768-2

INTRODUCTION

The development of evidence-based recommendations for both cancer screening and genetic counseling and testing for cancer risk holds promise for the prevention and early detection of many cancers.[1–3] The US Preventive Services Task Force (USPSTF) has published and widely disseminated independent, rigorous evaluations of the evidence and the balance of the benefits and harms of preventive services, including cancer screening.[4] Yet appropriate application of these recommendations is complex. Health care providers first must gather the information needed for risk assessment, including family and personal history of cancer, and demographics (e.g., age, ethnicity), then estimate the patient's cancer risk. Based on this estimated risk, physicians can discuss and educate their patients about the risks and benefits of screening, and genetic counseling and testing if indicated, then conduct or refer for appropriate testing and/or counseling. Physicians report that when patients expect to have cancer screening tests or are anxious about cancer, they order these tests more often.[5]

Accurate risk assessment is important so that women at average cancer risk undergo routine cancer screening only, and not unnecessary testing (e.g., more frequent colorectal cancer screening, genetic counseling), and so that women at higher than average cancer risk do not forego testing (e.g., genetic counseling, testing) that can prevent cancers. Until now, much of the published literature on cancer risk assessment and its application in practice has focused on physician elicitation of family history data, and their referral patterns for genetic counseling and testing for cancers with available genetic marker testing (e.g., breast, colon).[6–11] This research has demonstrated that providers do not consistently gather enough family history information to

adequately assess risk,[6,7,11–15] and that patients, who frequently underestimate or overestimate their cancer risk,[16–18] may not accurately report family history of cancer.[19] Primary care providers, while interested in playing a role in genetic counseling and testing, are not necessarily knowledgeable about hereditary cancers,[20–22] and do not necessarily make effective use of available family history.[23] Studies have shown mismatch between published recommendations and reported referral for genetic counseling and testing,[24–26] as well as mismatch between recommendations against routine ovarian cancer screening and physician reported screening practices.[27] Further research is needed to understand the reasons for these mismatches—whether providers are inaccurately assessing patients' cancer risks, are unaware of the indications for routine screening or genetic counseling and testing, or disagree with published recommendations.

This study helps fill one of these research gaps by using the results of the Women's Health Survey of family physicians, general internists, and obstetrician-gynecologists to answer the question: To what degree do U.S. physicians accurately categorize ovarian and colon cancer risk based on a patient's family and personal cancer history and demographic data? We hypothesized that physicians would frequently miscategorize patient cancer risk, given prior research showing that physicians report screening women at average risk for ovarian cancer, and that women with family or personal histories suggestive of BRCA 1/2 risk are often not referred for genetic counseling or testing.[24–30]

METHODS

Study Survey and Design

The Women's Health Survey, conducted in fall 2008, was a cross-sectional survey of 3,200 family physicians, general internists, and obstetrician-gynecologists randomly sampled equally from the American Medical Association (AMA) Physician Masterfile. The AMA Physician Masterfile maintains demographic, contact, and education, training and professional certification information on virtually all U.S. Doctors of Medicine (MD) and Doctors of Osteopathic Medicine (DO).[31] The sampled physicians were ages 64 years and younger, and practiced in office or hospital-based settings. With a response rate of 61.7 %, and after exclusions, the study population included 1,555 physicians who completed training (i.e., residency, fellowship) and provided women's outpatient care. A full description of the survey methods (a modified Tailored Design Method[32]) have been published elsewhere.[27] This research study was approved by the University of Washington Human Subjects Division and the Centers for Disease Control and Prevention Institutional Review Board.

The 12-page mail questionnaire in the form of a survey booklet examined physicians' reported care for women's health. Each physician received a questionnaire that included three vignettes, one of which asked about provision of preventive care services at an annual examination. The physicians were randomized to 48 different versions of the annual examination vignette, varied by the woman's age (35 or 51 years), race (African-American or Caucasian), and insurance (Medicaid or private), whether the woman requested screening (requests cancer screening, especially for ovarian cancer or wants to be sure she is up to date on all appropriate cancer screening tests), and the woman's family and personal cancer history: (1) a paternal grandmother with ovarian cancer, a paternal first cousin with premenopausal breast cancer, and breast cancer herself at age 30 (much higher ovarian cancer risk than the general population [estimated 26.6 % risk of a deleterious genetic mutation using the Myriad Genetics risk calculator[33]; of those with BRCA1, a 46 % lifetime risk, and those with BRCA2, a 12 % lifetime risk of ovarian cancer[34]]); 2) a mother with ovarian cancer at age 62 (somewhat higher ovarian cancer risk than the general population [4.0 %–5.0 % lifetime ovarian cancer risk based on published estimates that used modified life-table estimation methods[35,36]]); 3) a mother with breast cancer at age 70 (same risk of ovarian cancer as the general population [roughly 1.4 % lifetime ovarian cancer risk based on published estimates from the Surveillance Epidemiology and End Results {SEER} Program[37]]). In all vignettes, the woman's colon cancer risk was the same as the general population, because no vignette included a family or personal history of conditions that routinely increase colon cancer risk or suggest that a physician should deviate from the USPSTF average-risk screening recommendations (e.g., hereditary colon cancer syndromes, personal history of colorectal cancer or adenomas, personal history of inflammatory bowel disease).[2] Physicians were asked to provide their best estimate of the woman's risk level for colon and ovarian cancer compared to the general population—the same as, somewhat higher than, or much higher. The questionnaire also elicited physician demographics, practice characteristics, attitudes towards risk, beliefs about cancer screening tests, sources of information about cancer screening, and non-professional cancer experience (Appendix 1, available online).

Study Variables

Outcome Variables. Each physician received a vignette representing a woman in one of three ovarian cancer risk groups, depending on her reported family and personal

history of cancer: much higher, somewhat higher, or the same as the general population. All vignettes portrayed women at the same colon cancer risk as the general population. We created variables that reflected study physicians' accuracy of estimating ovarian and colon cancer risk by identifying whether the physicians overestimated, underestimated, or correctly estimated the woman's level of ovarian cancer risk, and overestimated or correctly estimated her colon cancer risk.

Covariates. Patient Characteristics. Patient characteristics were varied in the vignette (see Study Survey and Design), and included age, race, insurance type, and request for ovarian cancer screening.

Physician Characteristics. Physician characteristics included factors that might influence their cancer screening intentions—belief about the clinical effectiveness of cancer screening tests (4-point Likert scale from strongly agree to strongly disagree), measures of attitude toward risk-taking and malpractice concern (7-point and 5-point Likert scales, respectively, from strongly agree to strongly disagree, based on original research that developed these measures),[38,39] and whether physicians listed the U.S. Preventive Services Task Force (USPSTF), the American College of Obstetrics and Gynecology (ACOG), the National Institutes of Health (NIH)/National Cancer Institute (NCI), or the American Cancer Society (ACS) within the top three organizations influencing their cancer screening recommendations (chosen from nine organizations relevant to the specialties surveyed, and a write-in option). We also included physician practice factors that might inhibit or support screening—geographic location (urban, large rural, or small/isolated small rural area [based on Rural Urban Commuting Area codes linked by physician ZIP code])[40,41]; census division; primary practice setting (e.g., office practice, community health center); group/solo practice type; involvement in clinical teaching; average number of outpatients seen weekly; and board certification. Last, we measured other physician characteristics associated with cancer screening (i.e., age, sex, years in practice, specialty), and that we hypothesized might be associated with cancer risk estimation (i.e., non-professional cancer experience: none, with a family member/close friend/co-worker only, the physician's own cancer experience).

We compared respondents and non-respondents on variables available through the AMA Physician Masterfile (physician specialty, sex, age, and present employment), and found differences only by "present employment" type (for respondents and non-respondents: group practice 69.3 % versus 63.6 %, self-employed 17.7 % versus 22.2 %, government 6.9 % versus 7.0 %, and other 6.1 % versus 7.2 %, respectively, $P=0.02$).

Analysis

We used SUDAAN 10.0 (RTI International, Research Triangle Park, NC) to weight the responses of family physicians, general internists, and obstetrician-gynecologists to their representative number in the practicing U.S. physician population using AMA Physician Masterfile counts. We examined the rate at which physicians overestimated, underestimated, or accurately estimated the ovarian cancer risk of women at the three levels of true ovarian cancer risk, and overestimated or accurately estimated the colon cancer risk of the women, all of whom had the same risk as the general population. We compared the percentage of over, under, and accurate risk assessment by patient, physician, and practice characteristics for ovarian and colon cancer, using $P\leq0.01$ to denote significance due to multiple comparisons. Stepwise multivariate logistic regression analysis identified the physician and practice characteristics independently, and significantly associated with overestimating or underestimating risk at the $P\leq0.05$ level after controlling for all patient characteristics. Physician and practice characteristics that were significantly associated in unadjusted analysis with overestimating or underestimating risk at the $P\leq0.05$ level were investigated for possible inclusion in the stepwise regression models. Because accurately estimating risk is a common outcome, we calculated risk ratios within SUDAAN based on predicted marginals.[42]

RESULTS

Characteristics of the Physician Study Sample

Our study sample included 41.8 % family physicians, 40.8 % general internists, and 17.4 % obstetrician-gynecologists (Table 1). Nearly half had been in practice over 20 years. Almost one-fourth were in solo practice. Over half (53.5 %) listed the USPSTF, 33.6 % NIH/NCI, 65.6 % ACS, and 31.1 % ACOG as one of the top three organizations influencing their cancer screening recommendations.

Ovarian Cancer Risk Assessment

Overall, 57.0 % of physicians correctly estimated the ovarian cancer risk of the woman portrayed in the vignette. However, there was substantial mismatch between physicians' estimates of cancer risk and patients' true cancer risk (Table 2). Over one-quarter (27.1 %) of physicians overestimated the ovarian cancer risk of a woman with the same risk level as the general population; 65.1 % underestimated the ovarian cancer risk of a woman with much higher risk than the general population. For the

Table 1. Characteristics of Physician Respondents and their Practices

Physician and practice characteristics	All physicians[a] N=1,555
	% (95 % CI)
Age	
30–39	23.0 (20.8, 25.3)
40–49	34.4 (31.9, 37.0)
50–64	42.6 (40.0, 45.3)
Race	
Caucasian	73.4 (70.9, 75.8)
Asian/Pacific Islander	16.4 (14.4, 18.6)
African American	5.3 (4.2, 6.6)
Other	4.9 (3.9, 6.3)
Hispanic ethnicity	4.9 (3.8, 6.2)
Female sex	40.4 (37.8, 43.0)
Primary specialty	
Family medicine	41.8 (41.5, 42.0)
General internal medicine	40.8 (40.5, 41.1)
Obstetrics-gynecology	17.4 (17.3, 17.6)
Board certification	91.7 (90.1, 93.1)
Years in practice	
0–10	17.9 (16.0, 20.0)
11–20	37.7 (35.1, 40.3)
21+	44.5 (41.8, 47.2)
Primary practice setting	
Office practice or freestanding clinic	80.0 (77.7, 82.1)
Urgicenter	1.7 (1.1, 2.5)
Hospital outpatient department	5.9 (4.7, 7.3)
Health maintenance organization or other prepaid practice	2.6 (1.9, 3.6)
Community health center, non-federal government clinic, tribal health center/Indian Health Service	4.1 (3.2,5.4)
Federal government-operated clinic	2.8 (2.0, 3.9)
Other, including institutional setting, family planning clinic	2.9 (2.1,4.0)
Practice type	
Solo practice	23.6 (21.4, 26.0)
Group practice	73.5 (71.1, 75.9)
Other	2.8 (2.0, 3.9)
Weekly average number of patients	
1–60	27.3 (24.9, 29.8)
61–90	28.9 (26.5, 31.4)
91+	43.9 (41.2, 46.5)
Involved in clinical teaching	40.3 (37.7, 43.0)
Non-professional experience with cancer	
Family (immediate or extended), close friend, co-worker	78.9 (76.6, 81.0)
Self	4.7 (3.7, 6.0)
None	16.4 (14.5, 18.5)
Geographic location	
Urban	84.6 (82.6, 86.3)
Large rural	9.3 (7.9, 11.0)
Small/remote rural	6.1 (5.0, 7.5)
Census division	
New England	5.6 (4.5, 7.1)
Middle Atlantic	14.1 (12.3, 16.1)
East north central	16.7 (14.8, 18.8)
West north central	7.9 (6.6, 9.4)
South Atlantic	16.1 (14.3, 18.2)
East south central	5.6 (4.5, 6.9)
West south central	9.1 (7.7, 10.7)
Mountain	7.0 (5.7, 8.5)
Pacific	17.9 (15.9, 20.1)
Level of risk taking	
Low (6–17)	58.1 (55.3, 60.8)
Medium (18–24)	34.3 (31.7, 36.9)
High (25+)	7.6 (6.3, 9.2)
Fear of malpractice	
Low (2–4)	14.1 (12.2, 16.2)
Medium (5–7)	28.0 (25.6, 30.5)
High (8+)	57.9 (55.2, 60.6)
Listed U.S. Preventive Services Task Force (USPSTF) among top 3 sources of cancer screening information[b]	53.5 (50.8, 56.1)
Listed National Institutes of Health (NIH)/ National Cancer Institute (NCI) among top 3 sources of cancer screening information[b]	33.6 (31.2, 36.2)
Listed American College of Obstetricians and Gynecologists (ACOG) among top 3 sources of cancer screening information[b]	31.1 (29.2, 33.0)
Listed American Cancer Society (ACS) among top 3 sources of cancer screening information[b]	65.6 (63.0, 68.1)
Reported believing transvaginal ultrasound (TVU) is clinically effective in screening for ovarian cancer[c]	30.2 (27.7, 32.7)
Reported believing cancer antigen 125 (CA125) is clinically effective in screening for ovarian cancer[c]	17.7 (15.6, 19.9)
Reported believing either TVU or CA125 is clinically effective in screening for ovarian cancer[c]	33.6 (31.1, 36.2)

Missing data: race 49; Hispanic ethnicity 24; board certification 8; primary setting 18; practice type 15; weekly average number of patients 23; involved in clinical teaching 8; non-professional experience with cancer 21; level of risk taking 63; fear of malpractice 58; listed USPSTF, NIH/NCI, ACOG, or ACS among top 3 sources of cancer screening information 21; believed TVU clinically effective in screening for ovarian cancer 20; believed CA125 clinically effective in screening for ovarian cancer 24; believed either TVU or CA125 clinically effective in screening for ovarian cancer 16

CI confidence interval

[a] *Results in Table 1 were adjusted using weights to represent the specialty distribution of the practicing U.S. physician population*

[b] *Chosen from a list of nine organizations: American Academy of Family Physicians, American Cancer Society, American College of Obstetricians and Gynecologists, American College of Physicians/ American Society of Internal Medicine, American College of Surgeons, American Medical Association, National Institutes of Health/National Cancer Institute, U.S. Preventive Services Task Force, local institution (e.g., Health Maintenance Organization)*

[c] *Strongly agree or agree that these tests are clinically effective in screening for ovarian cancer in the average risk population*

vignettes depicting women at somewhat higher risk of ovarian cancer, physicians were over four times more likely to overestimate (32.3 %) than underestimate (7.3 %) ovarian cancer risk.

Accuracy of ovarian cancer risk estimation was largely consistent across patient and physician characteristics (Table 3, Appendices 2 and 3 [available online]). For the vignette of a woman whose true risk was the same as the general population, there were only two significant predictors of overestimating ovarian cancer risk: 1) specialty—obstetrician-gynecologists were less likely than general internists to overestimate (adjusted RR [aRR] 0.56, CI 0.38, 0.83); and 2) beliefs—those who believed that transvaginal ultrasound or cancer antigen 125 (CA125) was an effective ovarian cancer screening test were more likely to overestimate than those who did not (aRR 1.58, CI 1.15, 2.16). For women at much higher ovarian cancer risk than the general population, physicians in small or remote rural

Table 2. Physician Estimated Risk by True Patient Risk of Ovarian and Colon Cancer

Patient true risk compared to the general population:	*N*	Physician estimated risk compared to the general population:		
		Same	Somewhat higher	Much higher
		% (95 % CI)	% (95 % CI)	% (95 % CI)
Ovarian				
Same	505	72.9 (68.4, 77.0)	25.8 (21.8, 30.3)	1.3 (0.6, 2.9)
Somewhat higher	587	7.3 (5.5, 9.7)	60.4 (56.0, 64.5)	32.3 (28.4, 36.6)
Much higher	457	11.0 (8.3, 14.5)	54.1 (49.1, 59.0)	34.9 (30.3, 39.8)
Colon				
Same[a]	1,536	62.0 (59.4, 64.6)	33.2 (30.8, 35.8)	4.7 (3.7, 6.0)

Results were adjusted using weights to represent the specialty distribution of the practicing U.S. physician population
CI confidence interval
[a]*The percentages reported do not sum to 100 % due to data rounding*

areas were significantly more likely to underestimate risk than urban physicians (aRR 1.52, CI 1.33, 1.75).

For women at somewhat higher ovarian cancer risk than the general population, specialty was the only significant predictor of underestimating ovarian cancer risk (Table 3), with obstetrician-gynecologists significantly more likely to underestimate ovarian cancer risk than family physicians and general internists (aRR 2.40, CI 1.33, 4.33, and 3.38, CI 1.66–6.89, respectively). Predictors of overestimating ovarian cancer risk included belief in CA125 as an ovarian cancer screening test, use of NIH/NCI and ACOG as top organizations influencing cancer screening recommendations, and physician age. Physicians who believed in CA125 as an ovarian cancer screening test were more likely than those who did not to overestimate ovarian cancer risk (aRR 1.55, CI 1.20, 2.02); physicians who listed NIH/NCI as a top organization influencing their cancer screening recommendations were less likely than those who did not to overestimate ovarian cancer risk (aRR 0.59, CI 0.43, 0.81). Physicians ages 50–64 years were significantly more likely to overestimate ovarian cancer risk than those ages 30–39 years (aRR 1.51, CI 1.06, 2.15); physicians who listed the ACOG as a top organization influencing their cancer screening recommendations were significantly less likely to overestimate risk than those who did not (aRR 0.75, CI 0.57, 0.99).

Colon Cancer Risk Assessment

Physicians were more likely to overestimate colon cancer risk (38.0 % [CI 35.4, 40.6]) than ovarian cancer risk (27.1 % [CI 23.0, 31.6]). Overall, however, 62.0 % of physicians correctly estimated colon cancer risk in the vignette (Table 2). Physicians were more likely to overestimate colon cancer risk for African-American than for Caucasian women (Table 4: aRR 1.30, CI 1.1, 1.49), or for women with a personal history of breast cancer (aRR 2.14, CI 1.88, 2.43). Women physicians were more likely than men (aRR 1.15, CI 1.01, 1.32), and obstetrician-gynecologists more likely than family physicians (aRR 1.27, CI 1.11, 1.46) to overestimate colon cancer risk.

DISCUSSION

In this vignette-based survey, the majority of physicians accurately assessed women's risk of ovarian (56.9 %) and colon cancer (62.0 %). Notably, however, sizeable proportions of physicians overestimated and underestimated ovarian cancer risk and overestimated colon cancer risk. Several patient and physician characteristics were significantly associated with individual measures of overestimation or underestimation of cancer risk in our adjusted analyses, but there were no consistent findings across our measured outcomes.

The few studies that have examined physicians' ability to assess patients' cancer risks[25,28–30] found similar misestimation rates. Physicians have demonstrated particular difficulty with accurately judging the cancer risk of individuals with more than one or two relatives with a relevant cancer.[30] This is consistent with our finding that a powerful predictor of overestimating colon cancer was the patient's personal history of breast cancer, even though there is no clear evidence that this increases a woman's colon cancer risk.[43]

Both overestimating and underestimating cancer risk has important clinical implications. Overestimating cancer risk can lead to overuse of screening and genetic testing. Routine screening of women at average risk for ovarian cancer with CA-125 or transvaginal ultrasound is not recommended.[44] These tests have high false positive and low positive predictive values for average risk women,[45,46] and do not improve ovarian cancer's morbidity and mortality.[46–62] Contrary to recommendations, sizeable proportions of physicians have reported offering ovarian cancer screening to average risk women, and physician estimation that a woman was at

Table 3. Multivariate Regression: Predictors of Ovarian Cancer Risk Misestimation

	True ovarian cancer risk			
	Same as the general population *N*=505	Somewhat higher than the general population[a] *N*=587		Much higher than the general population *N*=457
	Predictors of overestimating risk	Predictors of underestimating risk	Predictors of overestimating risk	Predictors of underestimating risk
	RR (95 % CI)	RR (95 % CI)	RR (95 % CI)	RR (95 % CI)
Patient characteristics				
Age (years)				
51 vs. 35	1.06 (0.77, 1.46)	0.75 (0.44, 1.29)	1.09 (0.85, 1.40)	1.11 (0.96, 1.28)
Race				
African American vs. Caucasian	0.93 (0.68, 1.27)	0.63 (0.37, 1.06)	1.10 (0.85, 1.42)	1.00 (0.86, 1.15)
Insurance				
Medicaid vs. private	0.87 (0.63, 1.19)	0.73 (0.42, 1.26)	1.08 (0.84, 1.38)	0.89 (0.77, 1.03)
Patient requests screening				
Yes vs. no	0.85 (0.62, 1.17)	1.26 (0.73, 2.18)	1.12 (0.87, 1.43)	1.05 (0.90, 1.21)
Physician characteristics				
Primary specialty				
OB vs. FP	0.75 (0.50, 1.10)	**2.40 (1.33, 4.33)**		
OB vs. IM	**0.56 (0.38, 0.83)**	**3.38 (1.66, 6.89)**		
TVU or CA125 test effectiveness				
Reported believing either TVU or CA125 is clinically effective in screening for ovarian cancer (yes vs. no)	**1.58 (1.15, 2.16)**			
CA125 test effectiveness				
Reported believing CA125 is clinically effective in screening for ovarian cancer (yes vs. no)			**1.55 (1.20, 2.02)**	
NIH use				
Yes vs. no			**0.59 (0.43, 0.81)**	
ACOG use				
Yes vs. no			**0.75 (0.57, 0.99)**	
MD age				
40–49 vs. 30–39			1.24 (0.84, 1.83)	
50–64 vs. 30–39			**1.51 (1.06, 2.15)**	
Geographic location				
Large rural vs. urban				1.19 (0.98, 1.45)
Small/remote rural vs. urban				**1.52 (1.33, 1.75)**

Missing data: non-professional experience with cancer 21; listed NIH/NCI or ACOG among top 3 sources of cancer screening information 21; CA125 clinically effective in screening for ovarian cancer 24; believed either TVU or CA125 clinically effective in screening for ovarian cancer 16
CI confidence interval
[a]*For the vignette with the woman at somewhat higher ovarian cancer risk, we conducted separate regression analyses to identify the predictors of overestimating ovarian cancer risk (including only physicians who accurately or overestimated ovarian cancer risk) and underestimating ovarian cancer risk (including only physicians who accurately or underestimated ovarian cancer risk)*

higher risk of ovarian cancer than the general population was one of the most powerful predictors of this finding.[27] Likewise, 28.7 % of physicians have reported recommending genetic counseling or BRCA1/2 testing for women who were not at high ovarian cancer risk, and their estimation of a woman's ovarian cancer risk was the most powerful predictor of this recommendation.[26] Overestimating colon cancer risk also could lead to overscreening. Many primary care providers reported recommending colorectal cancer screening at younger ages and at more frequent intervals than evidence-based guidelines indicate.[63] Overscreening related to overestimating colon cancer risk increases patient risks from tests and procedures, decreases capacity to screen individuals who meet evidence-based eligibility guidelines, and increases health care costs.

The underestimation of ovarian cancer risk found in this study is also problematic. Individuals with family histories suggesting a high risk of ovarian and breast cancers are more likely to have BRCA1/2 genetic mutations, and prophylactic surgery can prevent these cancers.[64] This study suggests that nationally, physicians underestimate ovarian cancer risk for roughly two-thirds of these women. Prior research has found that among women at high ovarian cancer risk, physicians who underestimated a woman's risk as the same as the general population reported referring or testing only 5.4 % of them, whereas physicians who accurately assessed women as high risk reported referring or testing 64.6 % of them.[26] Other studies have demonstrated that women at high risk of ovarian and breast cancer are not routinely offered the opportunity to

Table 4. Multivariate Regression: Predictors of Colon Cancer Risk Misestimation

	True colon cancer risk
	Same as the general population *N*=1,536
	Predictors of overestimating risk
	RR (95 % CI)
Patient characteristics	
Age (years)	
51 vs. 35	1.14 (1.00, 1.30)
Race	
African American vs. Caucasian	**1.30 (1.14, 1.49)**
Insurance	
Medicaid vs. private	1.09 (0.96, 1.24)
Patient requests screening	
Yes vs. no	0.92 (0.81, 1.05)
Patient personal history of breast cancer	
Yes vs. no	**2.14 (1.88, 2.43)**
Physician characteristics	
Primary specialty	
OB vs. FP	**1.27 (1.11, 1.46)**
OB vs. IM	1.10 (0.95, 1.27)
MD sex	
Male vs. female	**0.87 (0.76, 0.99)**

Missing data: non-professional experience with cancer 21; listed NIH/NCI or ACOG among top 3 sources of cancer screening information 21; CA125 clinically effective in screening for ovarian cancer 24; believed either TVU or CA125 clinically effective in screening for ovarian cancer 16
CI confidence interval

seek genetic counseling for BRCA1/2;[65,66] this study suggests that a major contributor may be inaccurate risk assessment.

This study's results are limited by its survey methods. The survey results may not generalize to non-respondents, though this survey had a high response rate, 61.7 %, and the respondents and non-respondents were comparable on most measured variables. We assessed the women's true cancer risks based only on family and personal history presented in the hypothetical vignette. Physicians in practice are able to elicit a more complete picture of patients and their health, which could influence risk assessment. Our prior research has shown that risk estimation is a powerful predictor of physician-reported cancer screening and referral for genetic counseling or testing;[26,27] additional research is needed to corroborate this with actual test ordering and referrals. Several variables that define overestimation and underestimation of cancer risk combine different degrees of misestimation. For example, physicians who overestimated ovarian cancer risk among women at the same risk as the general population either estimated their risk as somewhat or much higher. Our sample size does not allow us to differentiate these two types of risk overestimation. Additionally, the cancer risk estimation scale was one-sided, only including risk categories that were higher than the general population, which may have encouraged participants to overestimate cancer risk.

Additional limitations include this study's focus on women's health. We only surveyed physician specialties that provide primary care to women. It is possible that gastroenterologists would have been less likely to overestimate colon cancer risk. Also, our survey was conducted in 2008, and high profile news stories (e.g., Angelina Jolie)[67] may have increased patient and physician awareness of cancer risks, potentially increasing the accuracy of physician risk assessment. We did not include the National Comprehensive Cancer Network (NCCN) on the list of organizations that may have influenced physicians' cancer screening recommendations, because we surveyed only women's primary care providers. Thus the survey may have missed noting the NCCN as an influential organization. Finally, there are no clear definitions of "acceptable" cancer risk misestimation in the literature. The rates found in this study are clearly not ideal, but further work is needed to identify an attainable target for accuracy of cancer risk assessment.

A substantial proportion of physicians nationally may be inaccurately estimating ovarian and colon cancer risk, putting average risk patients in jeopardy of unnecessary screening and misdirection of health care resources, and higher risk patients in jeopardy of missed opportunities for prevention or early detection of cancers. Improving cancer risk assessment among U.S. health care providers will require a concerted national effort, and is important for accurate screening and appropriate use of the growing number of genetic tests.[68] This study's results offer a first step by informing training programs, professional organizations, and government agencies about the deficits in cancer risk assessment among physicians. The increasing use of electronic health records provides new, innovative opportunities for identifying at-risk patients, given the structured format in which age and family history can be entered into the record. Future research is needed to explore use of electronic health records for assessing individual patients' cancer risk and for notifying providers at a patient visit about evidence-based guidelines tailored to this risk.

Acknowledgements: Funding/Support: *This project was funded by the Centers for Disease Control and Prevention (CDC) through the University of Washington Health Promotion Research Centers Cooperative Agreement U48DP001911, and through the Alliance for Reducing Cancer, Northwest (ARC NW), funded by both the Centers for Disease Control and Prevention (CDC; Grant U48DP001911, V. Taylor, PI) and the National Cancer Institute (NCI). The findings and conclusions of this journal article are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.*

Prior Presentations: *"Accuracy of Cancer Risk Assessment by Family Physicians, General Internists, and Obstetrician-Gynecologists: A National Vignette-Based Survey" (Baldwin L-M, Trivers K, Andrilla CHA, Matthews B, Miller J, Lishner D, Goff B) was presented at the 40th North American Primary Care Research Group Annual Meeting, New Orleans, LA, 4 December 2012.*

Conflicts of Interest: *The authors declare that they do not have a conflict of interest.*

Corresponding Author: *Laura-Mae Baldwin, MD, MPH; Department of Family Medicine, University of Washington, Box 354982, Seattle, WA 98195-4982, USA (e-mail: lmb@uw.edu).*

REFERENCES

1. U.S. Preventive Services Task Force. Genetic risk assessment and BRCA mutation testing for breast and ovarian cancer susceptibility: recommendation statement. Ann Intern Med. 2005;143(5):355–61.
2. U.S. Preventive Services Task Force. Screening for colorectal cancer: U.S. Preventive Services Task Force recommendation statement. Ann Intern Med. 2008;149(9):627–37.
3. U.S. Preventive Services Task Force. Screening for breast cancer: U.S. Preventive Services Task Force recommendation statement. Ann Intern Med. 2009;151(10):716–26. W-236.
4. U.S. Preventive Services Task Force. About the USPSTF. Available at: http://www.uspreventiveservicestaskforce.org/about.htm. Accessed December 16, 2013.
5. **Haggerty J, Tudiver F, Brown JB, Herbert C, Ciampi A, Guibert R.** Patients' anxiety and expectations: how they influence family physicians' decisions to order cancer screening tests. Can Fam Physician. 2005;51:1658–9.
6. **Burke W, Culver J, Pinsky L, et al.** Genetic assessment of breast cancer risk in primary care practice. Am J Med Genet A. 2009;149A(3):349–56.
7. **Flynn BS, Wood ME, Ashikaga T, Stockdale A, Dana GS, Naud S.** Primary care physicians' use of family history for cancer risk assessment. BMC Fam Pract. 2010;11:45.
8. **Guerra CE, Sherman M, Armstrong K.** Diffusion of breast cancer risk assessment in primary care. J Am Board Fam Med. 2009;22(3):272–9.
9. **Murff HJ, Byrne D, Syngal S.** Cancer risk assessment: quality and impact of the family history interview. Am J Prev Med. 2004;27(3):239–45.
10. **Sabatino SA, McCarthy EP, Phillips RS, Burns RB.** Breast cancer risk assessment and management in primary care: provider attitudes, practices, and barriers. Cancer Detect Prev. 2007;31(5):375–83.
11. **Schroy PC 3rd, Barrison AF, Ling BS, Wilson S, Geller AC.** Family history and colorectal cancer screening: a survey of physician knowledge and practice patterns. Am J Gastroenterol. 2002;97(4):1031–6.
12. **Tyler CV Jr, Snyder CW.** Cancer risk assessment: examining the family physician's role. J Am Board Fam Med. 2006;19(5):468–77.
13. **Grover S, Stoffel EM, Bussone L, Tschoegl E, Syngal S.** Physician assessment of family cancer history and referral for genetic evaluation in colorectal cancer patients. Clin Gastroenterol Hepatol. 2004;2(9):813–9.
14. **Murff HJ, Greevy RA, Syngal S.** The comprehensiveness of family cancer history assessments in primary care. Community Genet. 2007;10(3):174–80.
15. **Sifri RD, Wender R, Paynter N.** Cancer risk assessment from family history: gaps in primary care practice. J Fam Pract. 2002;51(10):856.
16. **Herman JD, Herman SM.** Women's understanding of personal breast cancer risk: does ethnicity matter? J Clin Oncol. 2013;31(suppl 26):abstr 4.
17. **MacDonald DJ, Sarna L, Uman GC, Grant M, Weitzel JN.** Health beliefs of women with and without breast cancer seeking genetic cancer risk assessment. Cancer Nurs. 2005;28(5):372–9.
18. **Haas JS, Kaplan CP, Des Jarlais G, Gildengoin V, Perez-Stable EJ, Kerlikowske K.** Perceived risk of breast cancer among women at average and increased risk. J Womens Health (Larchmt). 2005;14(9):845–51.
19. **Qureshi N, Wilson B, Santaguida P, et al.** Collection and use of cancer family history in primary care. Evid Rep Technol Assess (Full Rep). 2007;159:1–84.
20. **Escher M, Sappino AP.** Primary care physicians' knowledge and attitudes towards genetic testing for breast-ovarian cancer predisposition. Ann Oncol. 2000;11(9):1131–5.
21. **Wideroff L, Vadaparampil ST, Greene MH, Taplin S, Olson L, Freedman AN.** Hereditary breast/ovarian and colorectal cancer genetics knowledge in a national sample of US physicians. J Med Genet. 2005;42(10):749–55.
22. **Mouchawar J, Klein CE, Mullineaux L.** Colorado family physicians' knowledge of hereditary breast cancer and related practice. J Cancer Educ. 2001;16(1):33–7.
23. **Wood ME, Flynn BS, Stockdale A.** Primary care physician management, referral, and relations with specialists concerning patients at risk for cancer due to family history. Public Health Genomics. 2013;16(3):75–82.
24. **Bellcross CA, Leadbetter S, Alford SH, Peipins LA.** Prevalence and healthcare actions of women in a large health system with a family history meeting the 2005 USPSTF recommendation for BRCA genetic counseling referral. Cancer Epidemiol Biomarkers Prev. 2013;22(4):728–35.
25. **Bellcross CA, Kolor K, Goddard KA, Coates RJ, Reyes M, Khoury MJ.** Awareness and utilization of BRCA1/2 testing among U.S. primary care physicians. Am J Prev Med. 2011;40(1):61–6.
26. **Trivers KF, Baldwin LM, Miller JW, et al.** Reported referral for genetic counseling or BRCA 1/2 testing among United States physicians: a vignette-based study. Cancer. 2011;117(23):5334–43.
27. **Baldwin LM, Trivers KF, Matthews B, et al.** Vignette-based study of ovarian cancer screening: do U.S. physicians report adhering to evidence-based recommendations? Ann Intern Med. 2012;156(3):182–94.
28. **Fry A, Campbell H, Gudmunsdottir H, et al.** GPs' views on their role in cancer genetics services and current practice. Fam Pract. 1999;16(5):468–74.
29. **Haas JS, Kaplan CP, Gregorich SE, Perez-Stable EJ, Des Jarlais G.** Do physicians tailor their recommendations for breast cancer risk reduction based on patient's risk? J Gen Intern Med. 2004;19(4):302–9.
30. **Rose PW, Watson E, Yudkin P, et al.** Referral of patients with a family history of breast/ovarian cancer—GPs' knowledge and expectations. Fam Pract. 2001;18(5):487–90.
31. American Medical Association. AMA Physician Masterfile. Available at: http://www.ama-assn.org/ama/pub/about-ama/physician-data-resources/physician-masterfile.page. Accessed December 16, 2013.
32. **Dillman DA.** Mail and Internet Surveys: The Tailored Design Method. 2nd ed. Hoboken: Wiley; 2007.
33. Myriad Genetics. BRCA risk calculator. Available at: https://www.myriadpro.com/treating-diseases/hereditary-cancer-testing/hereditary-breast-and-ovarian-cancer-hboc-syndrome/brca-risk-calculator/. Accessed December 16, 2013.
34. ACOG Committee on Practice Bulletins. Hereditary breast and ovarian cancer syndrome. Gynecol Oncol. 2009;113(1):6–11.
35. **Kerlikowske K, Brown JS, Grady DG.** Should women with familial ovarian cancer undergo prophylactic oophorectomy? Obstet Gynecol. 1992;80(4):700–7.
36. **Schildkraut JM, Thompson WD.** Familial ovarian cancer: a population-based case–control study. Am J Epidemiol. 1988;128(3):456–66.
37. National Cancer Institute. SEER stat fact sheets: ovary. Available at: http://seer.cancer.gov/statfacts/html/ovary.html. Accessed December 16, 2013.
38. **Franks P, Williams GC, Zwanziger J, Mooney C, Sorbero M.** Why do physicians vary so widely in their referral rates? J Gen Intern Med. 2000;15(3):163–8.
39. **Katz DA, Williams GC, Brown RL, et al.** Emergency physicians' fear of malpractice in evaluating patients with possible acute cardiac ischemia. Ann Emerg Med. 2005;46(6):525–33.
40. **Morrill R, Cromartie J, Hart LG.** Metropolitan, urban, and rural commuting areas: toward a better depiction of the US settlement system. Urban Geogr. 1999;20(8):727–48.
41. Economic Research Service. Measuring rurality: Rural-urban Commuting Area Codes. Available at: http://www.ers.usda.gov/briefing/Rurality/RuralUrbanCommutingAreas/. Accessed December 16, 2013.
42. **Bieler GS, Brown GG, Williams RL, Brogan DJ.** Estimating model-adjusted risks, risk differences, and risk ratios from complex survey data. Am J Epidemiol. 2010;171(5):618–23.
43. **Newschaffer CJ, Topham A, Herzberg T, Weiner S, Weinberg DS.** Risk of colorectal cancer after breast cancer. Lancet. 2001;357(9259):837–40.
44. **Moyer VA, Force USPST.** Screening for ovarian cancer: U.S. Preventive Services Task Force reaffirmation recommendation statement. Ann Intern Med. 2012;157(12):900–4.
45. **Buys SS, Partridge E, Black A, et al.** Effect of screening on ovarian cancer mortality: the Prostate, Lung, Colorectal and Ovarian (PLCO) Cancer Screening Randomized Controlled Trial. JAMA. 2011;305(22):2295–303.

46. **Buys SS, Partridge E, Greene MH, et al.** Ovarian cancer screening in the Prostate, Lung, Colorectal and Ovarian (PLCO) cancer screening trial: findings from the initial screen of a randomized trial. Am J Obstet Gynecol. 2005;193(5):1630–9.
47. National Institutes of Health Consensus Development Conference Statement. Ovarian cancer: screening, treatment, and follow-up. Gynecol Oncol. 1994;55(3 Pt 2):S4–14.
48. **Buys SS, Partridge E, Black A, Johnson CC, Lamerato L, Isaacs C, Reding DJ, Greenlee RT, Yokochi LA, Kessel B, Crawford ED, Church TR, Andriole GL, Weissfeld JL, Fouad MN, Chia D, O'Brien B, Ragard LR, Clapp JD, Rathmell JM, Riley TL, Hartge P, Pinsky PF, Zhu CS, Izmirlian G, Kramer BS, Miller AB, Xu JL, Prorok PC, Gohagan JK, Berg CD**. PLCO Project Team. Effect of screening on ovarian cancer mortality: the Prostate, Lung, Colorectal and Ovarian (PLCO) Cancer Screening Randomized Controlled Trial. JAMA. 2011;305(22):2295–303.
49. **Fishman DA, Cohen L, Blank SV, et al.** The role of ultrasound evaluation in the detection of early-stage epithelial ovarian cancer. Am J Obstet Gynecol. 2005;192(4):1214–21. discussion 21-2.
50. **Goff BA, Muntz HG.** Screening and early diagnosis of ovarian cancer. Women's Health in Primary Care. 2005;8(6):262–8.
51. **Jacobs I, Davies AP, Bridges J, et al.** Prevalence screening for ovarian cancer in postmenopausal women by CA 125 measurement and ultrasonography. BMJ. 1993;306(6884):1030–4.
52. **Jacobs IJ, Menon U.** Progress and challenges in screening for early detection of ovarian cancer. Mol Cell Proteomics. 2004;3(4):355–66.
53. **Liede A, Karlan BY, Baldwin RL, Platt LD, Kuperstein G, Narod SA.** Cancer incidence in a population of Jewish women at risk of ovarian cancer. J Clin Oncol. 2002;20(6):1570–7.
54. **Menon U, Jacobs IJ.** Ovarian cancer screening in the general population. Curr Opin Obstet Gynecol. 2001;13(1):61–4.
55. **Olivier RI, Lubsen-Brandsma MA, Verhoef S, van Beurden M.** CA125 and transvaginal ultrasound monitoring in high-risk women cannot prevent the diagnosis of advanced ovarian cancer. Gynecol Oncol. 2006;100(1):20–6.
56. **Paley PJ.** Ovarian cancer screening: are we making any progress? Curr Opin Oncol. 2001;13(5):399–402.
57. **Partridge E, Kreimer AR, Greenlee RT, et al.** Results from four rounds of ovarian cancer screening in a randomized trial. Obstet Gynecol. 2009;113(4):775–82.
58. **Petricoin EF, Ardekani AM, Hitt BA, et al.** Use of proteomic patterns in serum to identify ovarian cancer. Lancet. 2002;359(9306):572–7.
59. **Skates SJ, Horick N, Yu Y, et al.** Preoperative sensitivity and specificity for early-stage ovarian cancer when combining cancer antigen CA-125II, CA 15-3, CA 72-4, and macrophage colony-stimulating factor using mixtures of multivariate normal distributions. J Clin Oncol. 2004;22(20):4059–66.
60. **van der Velde NM, Mourits MJ, Arts HJ, et al.** Time to stop ovarian cancer screening in BRCA1/2 mutation carriers? Int J Cancer. 2009;124(4):919–23.
61. **van Nagell JR, Jr DePriest PD, Reedy MB, et al.** The efficacy of transvaginal sonographic screening in asymptomatic women at risk for ovarian cancer. Gynecol Oncol. 2000;77(3):350–6.
62. **Woodward ER, Sleightholme HV, Considine AM, Williamson S, McHugo JM, Cruger DG.** Annual surveillance by CA125 and transvaginal ultrasound for ovarian cancer in both high-risk and population risk women is ineffective. BJOG. 2007;114(12):1500–9.
63. **Klabunde CN, Lanier D, Nadel MR, McLeod C, Yuan G, Vernon SW.** Colorectal cancer screening by primary care physicians: recommendations and practices, 2006-2007. Am J Prev Med. 2009;37(1):8–16.
64. **Domchek SM, Friebel TM, Singer CF, et al.** Association of risk-reducing surgery in BRCA1 or BRCA2 mutation carriers with cancer risk and mortality. JAMA. 2010;304(9):967–75.
65. **Baer HJ, Brawarsky P, Murray MF, Haas JS.** Familial risk of cancer and knowledge and use of genetic testing. J Gen Intern Med. 2010;25(7):717–24.
66. **Thompson HS, Sussner K, Schwartz MD, et al.** Receipt of genetic counseling recommendations among black women at high risk for BRCA mutations. Genet Test Mol Biomark. 2012;16(11):1257–62.
67. Jolie A. My medical choice. Available at: http://www.nytimes.com/2013/05/14/opinion/my-medical-choice.html. Accessed December 16, 2013.
68. **Khoury MJ, Bowen S, Bradley LA, et al.** A decade of public health genomics in the United States: Centers for Disease Control and Prevention 1997–2007. Public Health Genomics. 2009;12:20–9.