Factors Associated with Optimal Follow-up in Women with BI-RADS 3 Breast Findings

Ronilda Lacson¹,², Aijia Wang¹, Laila Cochon¹, Catherine Giess¹,², Sonali Desai²,³, Sunil Eappen²,⁴, Ramin Khorasani¹,²

¹Center for Evidence-Based Imaging, Department of Radiology, Brigham and Women’s Hospital, Boston MA,
²Harvard Medical School, Boston MA,
³Department of Medicine, Brigham and Women’s Hospital, Boston MA
⁴Department of Anesthesiology, Brigham and Women’s Hospital, Boston MA

Abstract

Objective: Assess rate of and factors associated with optimal follow-up in patients with BI-RADS 3 breast findings.

Methods: This Institutional Review Board-approved, retrospective cohort study, performed at an academic medical center, included all women undergoing breast imaging (ultrasound and mammography) in 2016. Index reports for unique patients with an assessment of BI-RADS 3 (retrieved via natural language processing) comprised the study population. Patient-specific and provider-related features were extracted from the Research Data Warehouse. The Institutional Cancer Registry identified patients diagnosed with breast cancer. Optimal follow-up rate was calculated as patients with follow-up imaging on the same breast 3–9 months from the index exam among patients with BI-RADS 3 assessments. Univariate analysis and multivariable logistic regression determined features associated with optimal follow-up. Malignancy rate and time to malignancy detection was recorded.

Results: Among 93,685 breast imaging exams, 64,771 were from unique patients of which 2,967 had BI-RADS 3 findings (4.6%). Excluding patients with off-site index exams and those with another breast exam <3 months from the index, 1,125 of 1,511 patients (74%) had optimal follow-up. In univariate and multivariable analysis, prior breast cancer was associated with optimal follow-up; younger age, Hispanic ethnicity, divorced status, and lack of insurance with not having optimal follow-up. Malignancy rate=0.86%; mean time to detection=330 days.

Discussion: Follow-up of BI-RADS 3 breast imaging findings is optimal in only 74% of women. Further interventions to promote follow-up should target younger, unmarried women, those with Hispanic ethnicity, and women without history of breast cancer and without insurance coverage.
Summary Statement:

In this study at a large health system conducting over 90,000 breast examinations annually, only 74% of women assessed to have BI-RADS 3 on an index breast examination had optimal follow-up as recommended.

Keywords

Breast imaging; BI-RADS; Follow-up; Mammography; Health disparities

Introduction

Optimal diagnostic follow-up is critical in order to address the National Academy of Medicine’s mandate for health care professionals to improve the diagnostic testing process. (1) A published study analyzing litigation cases from 2009–2013 showed that 20% alleged a diagnosis-related error as the primary reason for a lawsuit.(2) Thirty-one percent of diagnosis-related errors involve a failure or delay in ordering, scheduling and executing diagnostic tests,(2) including 45% involving diagnostic imaging.(3) Cancer is one of the leading missed diagnoses resulting from this failure or delay in diagnostic imaging.(3)

Breast cancer screening is a mainstay of public health in the United States. Over 33 million women a year receive mammograms, representing an estimated 60% of all women age 40 and over.(4) Previous studies have demonstrated a 20–30% reduction in breast cancer mortality with regular screening that results in further management. At a study performed between 1995–1997 at an academic medical center, the most common Breast Imaging Reporting and Data System (BI-RADS) assessment leading to a breast lesion biopsy was a BI-RADS category 3.(5) Recommendations for category 3 breast findings on mammography typically include 6-month follow-up imaging, followed by 12- and then 24-month follow-up imaging.(6–8) However, follow-up imaging has been sub-optimal in many women with breast imaging not performed to follow-up BI-RADS 3 lesions in the recommended time frame.(9–12) Since BI-RADS 3 breast lesions have up to 2% likelihood of malignancy (BI-RADS lexicon 5th ed), it is imperative that optimal follow-up of BI-RADS 3 test results be addressed to avoid this potential source of diagnostic imaging failure. We define optimal follow-up as having a follow-up breast exam completed 3–9 months from an index exam with a BI-RADS 3 assessment, as described previously.(13)

Factors that have been assessed that hinder optimal breast imaging follow-up include low patient income and lack of insurance coverage.(14) Patient demographics and referring provider characteristics (e.g., referring provider specialty) have contributed to enhancing timely management of abnormal test results and screening recall rates.(15, 16) However, no studies that comprehensively assessed patient- and provider-related factors have focused on optimal BI-RADS 3 follow-up, including time to malignancy detection. Therefore, we assessed the rate of optimal follow-up and patient- and provider-related factors associated with optimal follow-up in patients with BI-RADS 3 breast findings.
Methods

Setting and Population

The Institutional Review Board approved this HIPAA-compliant, retrospective cohort study and waived the requirement for informed consent. We conducted a 12-month study (January 1, 2016 – December 31, 2016) at a tertiary academic medical center, with an affiliated community hospital and a cancer institute, and an outpatient network that spans 183 practices and 1,200 physicians. The entire study site conducts over 500,000 diagnostic imaging examinations annually. The study population included all adult patients who completed a breast imaging examination, both screening and diagnostic, during the study period, including ultrasound (US) and 3D digital mammography. Index reports performed at the study site with an assessment of BI-RADS 3 and belonging to unique patients comprised the study population.

Data Collection

All radiology reports corresponding to eligible breast imaging during the study period were retrieved from the imaging data repository populated by Epic (Epic Systems Corporation, Madison, WI). The Institutional Research Data Warehouse was used to extract: (1) patient-specific features including age, race, marital status, previous breast cancer and other concurrent malignancies, as well as insurance coverage; and (2) provider-related features, including referring provider site (i.e., urban academic medical center, community teaching hospital, cancer institute, or outpatient facilities), and referring provider specialty (e.g., medicine, surgery, obstetrics). Referring provider site was coded as “other” for referring providers with no listed affiliations. In addition, diagnostic exams performed at outside facilities and documented in physician notes were noted. Other information extracted from the imaging data repository included presence of follow-up breast imaging within one year from the index report date, performed on the same breast. Modality was classified into mammography (with or without ultrasound) and ultrasound alone. The Institutional Cancer Registry was used to identify patients diagnosed with breast cancer at the study institution. BI-RADS 3 assessment and breast density were retrieved using a natural language processing application that has been previously validated.(17, 18) Breast density was analyzed as a binary variable (dense vs. non-dense).(19)

Outcome Measures and Data Analysis

The unit of analysis included unique patients who had eligible breast imaging exams with BI-RADS 3 findings. The primary outcome measure - rate of optimal follow-up - was calculated as all patients with follow-up breast imaging 3–9 months from the index exam out of all patients with BI-RADS 3 findings in an index exam within the study period. Patients with follow-up performed after 9 months, and those with no-follow-up up to one year from the index exam, were counted as not having optimal follow-up (i.e., suboptimal follow-up). Patients with breast imaging within 3 months from the index exam were excluded from analysis because these examinations may have been performed for other reasons, given that they are earlier than recommended for BI-RADS 3 findings.
A secondary outcome - malignancy rate - was recorded for the study cohort as all patients diagnosed with breast cancer as of December 31, 2017. Time to malignancy detection was recorded, including the mean time for all patients in the study cohort as well as the mean time for those with optimal follow-up and those without (i.e., suboptimal follow-up).

Univariate analysis was performed on all patient-related and provider-related factors collected, using chi-square statistic for categorical variables and logistic regression for continuous variables. Multivariable logistic regression was used to assess optimal follow-up by modeling patient- and provider-related factors. T-test was used to assess time to malignancy detection. We used the presence of optimal follow-up as the outcome variable for our model. SAS software version 9.3 was used for all statistical analyses (SAS Institute Inc, Cary NC). Significance level was defined as a p-value less than 0.05.

Results

Study Cohort

In 2016, a total of 93,685 breast imaging exams were performed for 64,771 unique women. Of these, 5,229 exams (5.6%) were given a BI-RADS 3 assessment, 2,967 (4.6%) of which were from unique patients. Excluding those with index exams performed elsewhere, 1,721 imaging reports belonging to unique women were included. Of these 1,721 reports, 135 (8%) were excluded as they had another breast imaging examination performed less than 3 months from the index exam and another 75 were excluded because they were breast MRI, leaving 1,511 imaging reports belonging to unique women (2.4%) in the study cohort.

Optimal Follow-up

1,125 of 1,511 women (74%) had optimal follow-up. 305 (20%) had no follow-up, and 103 (7%) had late follow-up that occurred 9+ months after the index exam.

Factors Associated with Optimal Follow-up

Patient and provider factors associated with optimal follow-up of BI-RADS 3 findings in univariate analysis are shown in Table 1. Breast density was not significantly associated with optimal follow-up and was omitted from the multivariable model (p=0.81). Mean age was older for women who had optimal follow-up. Married women also had more optimal follow-up compared to those who were single or divorced. Finally, women with prior breast cancer and those seen at the affiliated cancer institute received more optimal follow-up.

On multivariable analysis (Table 2), prior breast cancer and having a cancer institute as the referring provider site were significantly associated with more optimal follow-up. Younger patient age and divorced status were associated with less optimal breast imaging follow-up. Analysis considering race and ethnicity showed Asian women had more optimal follow-up while Hispanic women had less optimal follow-up, compared to White women. Finally, lack of insurance coverage was associated with less optimal follow-up.
Malignancy Rate

Malignancy rate was 13/1,511 (0.86%), concordant with the BI-RADS lexicon (BI-RADS lexicon 5th ed). 13 patients were detected to have cancer with at least one year of follow-up for the entire cohort. Mean time to detection was 330 days; 316 days for patients who had optimal follow-up, and 401 days for those with suboptimal follow-up (p=0.28).

Discussion

In this study at a large health system conducting over 90,000 breast examinations annually, only 74% of women assessed to have BI-RADS 3 on an index breast examination had optimal follow-up as recommended.(20) The suboptimal follow-up rate, 26%, is consistent with others reported, ranging between 12–33%.(9–12, 14) This finding is significant given the large number of women who undergo breast imaging annually.(4) Mean time to malignancy detection was 85 days longer for patients who did not receive optimal follow-up compared to those that did. However, this result was not statistically significant, likely due to small number of detected cancers in our cohort (n=13).

Prior breast cancer, older patient age, and married status were associated with optimal follow-up on univariate analysis and remained significant on multivariable analysis. Patients seen at a cancer institute and those who had insurance coverage also had more optimal follow-up. Previous studies have also noted more optimal follow-up in a group of women with prior history of breast cancer.(9) Perhaps the low rates of breast cancer among those with BI-RADS 3 findings(12) contribute to the less optimal follow-up in women who have never previously been diagnosed with breast cancer. Marital status appears to confer an advantage in having optimal follow-up. In a prior study of breast cancer patients, married women had better 5-year cancer-free and overall survival, compared to unmarried women. (21) The same improved survival advantage is seen in married women who have duodenal adenocarcinoma.(22) Finally, married woman are also more likely to be up-to-date with their colorectal cancer screening.(23) Perhaps, more attention should be focused on improving follow-up in unmarried women.

There is optimal follow-up for patients seen by referring providers at a cancer institute, likely because these patients already had cancer and are receiving closer follow-up. In addition, a cancer institute typically provides care coordination services to improve communication and care coordination for cancer patients.(24) A few providers did not have listed affiliations and their patients had less optimal follow-up on univariate analysis. However, this was not significant after adjusting for other variables.

Older age was associated with optimal follow-up, perhaps because younger women are less frequently diagnosed with breast cancer (6% in women aged 40–44, compared to 12% in women aged 50–54),(25) which may lead to lesser follow-up. However, addressing optimal follow-up in younger women is meaningful given that the risk of progression to invasive cancer in women with ductal carcinoma in situ is higher for younger women.(26) In addition, recommendations for breast screening begin at 40 to 45 years of age.(27)
Finally, Asians had more optimal breast imaging follow-up and Hispanic women had less optimal follow-up, even adjusting for all other confounders. Hispanic women have been noted previously to have less optimal mammography follow-up compared to non-Hispanic white women.(28) In all of our practice sites, we send letters to all patients with BI-RADS 3 reminding them to come for follow-up. However, all letters are sent in English and not translated to Spanish or any other language, even for patients who self-report as Hispanic. Anticipating that language may be an issue, we plan to send Spanish-translated letters in the future to women who self-report as Hispanic.

Lack of insurance coverage is also associated with less optimal follow-up, as reported previously:(14) Lack of insurance coverage is a key factor that impacts access to healthcare in addition to low income and low literacy. These social determinants of health have been estimated to account for 20% of premature deaths in the United States.(29) The effect of social determinants on cancer prevention is evident when examining disparities in mammography use. Sabatino et al noted that Hispanic women were less likely than non-Hispanic women to report to screening mammography (58.1% vs 69.0%), and low income, uninsured women continued to have the lowest rates of breast cancer screening.(30) We note both factors to be associated with less optimal follow-up as well. A care coordination system has been proven to enhance health processes, including facilitating screening for colorectal cancer and cervical cancer.(31) Perhaps a care coordination system that incorporates analytics and risk-estimation to identify persons at high risk for suboptimal follow-up could reduce follow-up disparities. In addition, more active management of unresolved BI-RADS 3 using electronic audit tools, commonly available in breast imaging practices, could be utilized. Future studies should focus on follow-up disparities so that effective interventions may be designed and implemented.

Limitations to our study include the retrospective nature of our data analysis. We did not assess indication for the exam. In addition, this study was performed in an academic medical center which may limit its generalizability. This study was limited to modalities of 3D digital mammography and ultrasound, as 3D mammography is being increasingly implemented as a screening tool to improve the sensitivity and specificity of screening mammography.(32, 33) In a previous study, the use of 3D mammography was associated with a higher odds of receiving a BI-RADS 3 assessment.(32)

Acknowledgements:
The authors would like to thank Ms. Laura Peterson for reviewing the manuscript.

Source of Support: This work was supported by Agency for Healthcare Research and Quality grant number R01HS024722. This study was also partly funded by CRICO Risk Management Foundation.

References

1. IOM. National Academies of Medicine. Improving Diagnosis in Health Care. http://www.nationalacademies.org/hmd/~~/media/Files/Report%20Files/2015/Improving-Diagnosis/DiagnosticError_ReportBrief.pdf. Last accessed April 2019 2015.
2. (CRICO) CRIC. 2014 CBS Report: Malpractice Risks in the Diagnostic Process2014 October 1, 2015. Available from: http://www.rmfstrategies.com/Clinician-Resources/Article/2014/CBS-Intro?sc_camp=0EB2AF4DEE834EB995C210A024A5DB29.
3. Gandhi TK, Kachalia A, Thomas EJ, Puopolo AL, Yoon C, Brennan TA, et al. Missed and delayed diagnoses in the ambulatory setting: a study of closed malpractice claims. Ann Intern Med. 2006;145(7):488–96. [PubMed: 17015866]

4. Breen N, Yabroff KR, Meissner HI. What proportion of breast cancers are detected by mammography in the United States? Cancer Detect Prev. 2007;31(3):220–4. [PubMed: 17573202]

5. Lacquement MA, Mitchell D, Hollingsworth AB. Positive predictive value of the Breast Imaging Reporting and Data System. J Am Coll Surg. 1999;189(1):34–40. [PubMed: 10401783]

6. Nelson HD, Tyne K, Naik A, Bougatsos C, Chan BK, Humphreys L, et al. Screening for breast cancer: an update for the U.S. Preventive Services Task Force. Ann Intern Med. 2009;151(10):727–37, W237–42. [PubMed: 19920273]

7. Elmore JG, Reisch LM, Barton MB, Barlow WE, Rolnick S, Harris EL, et al. Efficacy of breast cancer screening in the community according to risk level. J Natl Cancer Inst. 2005;97(14):1035–43. [PubMed: 16030301]

8. D’Orsi CJ, Sickles EA, Mendelson EB, Morris EA. ACR BI-RADS Atlas, Breast Imaging Reporting and Data System (BI-RADS). American College of Radiology 2013;5th ed.

9. Marshall AL, Domchek SM, Weinstein SP. Follow-up frequency and compliance in women with probably benign findings on breast magnetic resonance imaging. Acad Radiol. 2012;19(4):406–11. [PubMed: 22227041]

10. Chung CS, Giess CS, Gombos EC, Frost EP, Yeh ED, Raza S, et al. Patient compliance and diagnostic yield of 18-month unilateral follow-up in surveillance of probably benign mammographic lesions. AJR Am J Roentgenol. 2014;202(4):922–7. [PubMed: 24660725]

11. Helvie MA, Pennes DR, Rebner M, Adler DD. Mammographic follow-up of low-suspicion lesions: compliance rate and diagnostic yield. Radiology. 1991;178(1):155–8. [PubMed: 1984295]

12. Baum JK, Hanna LG, Achariya S, Mahoney MC, Conant EF, Bassett LW, et al. Use of BI-RADS 3-probably benign category in the American College of Radiology Imaging Network Digital Mammographic Imaging Screening Trial. Radiology. 2011;260(1):61–7. [PubMed: 21502382]

13. Aiello Bowles EJ, Miglioretti DL, Sickles EA, Abraham L, Carney PA, Yankasakas BC, et al. Accuracy of short-interval follow-up mammograms by patient and radiologist characteristics. AJR American journal of roentgenology. 2008;190(5):1200–8. [PubMed: 18430832]

14. Perez-Stable EJ, Afable-Munsuz A, Kaplan CP, Pace L, Samayoa C, Somkin C, et al. Factors influencing time to diagnosis after abnormal mammography in diverse women. J Womens Health (Larchmt). 2013;22(2):159–66. [PubMed: 23350859]

15. Hysong SJ, Sawhney MK, Wilson L, Sittig DF, Esquivel A, Singh S, et al. Understanding the management of electronic test result notifications in the outpatient setting. BMC Med Inform Decis Mak. 2011;11:22. [PubMed: 21486478]

16. Giess CS, Wang A, Ip IK, Lacson R, Pourjabbar S, Khorasani R. Patient, Radiologist, and Examination Characteristics Affecting Screening Mammography Recall Rates in a Large Academic Practice. J Am Coll Radiol. 2019;16(4 Pt A):411–8. [PubMed: 30037704]

17. Lacson R, Andriole KP, Prevedello LM, Khorasani R. Information from Searching Content with an Ontology-Utilizing Toolkit (iSCOUT). J Digit Imaging. 2012;25(4):512–9. [PubMed: 22349993]

18. Lacson R, Harris K, Brawarsky P, Tosteson TD, Onega T, Tosteson AN, et al. Evaluation of an Automated Information Extraction Tool for Imaging Data Elements to Populate a Breast Cancer Screening Registry. Journal of digital imaging. 2015.

19. Lehman CD, Yala A, Schuster T, Donthos B, Bahl M, Swanson K, et al. Mammographic Breast Density Assessment Using Deep Learning: Clinical Implementation. Radiology. 2019;290(1):52–8. [PubMed: 30325282]

20. Yasmeen S, Romano PS, Pettinger M, Chlebowski RT, Robbins JA, Lane DS, et al. Frequency and predictive value of a mammographic recommendation for short-interval follow-up. J Natl Cancer Inst. 2003;95(6):429–36. [PubMed: 12644536]

21. Liu YL, Wang DW, Yang ZC, Ma R, Li Z, Suo W, et al. Marital status is an independent prognostic factor in inflammatory breast cancer patients: an analysis of the surveillance, epidemiology, and end results database. Breast Cancer Res Treat. 2019.
22. Wang N, Bu Q, Liu Q, Yang J, He H, Liu J, et al. Effect of marital status on duodenal adenocarcinoma survival: A Surveillance Epidemiology and End Results population analysis. Oncol Lett. 2019;18(2):1904–14. [PubMed: 31423260]

23. Greiner KA, Engelman KK, Hall MA, Ellerbeck EF. Barriers to colorectal cancer screening in rural primary care. Prev Med. 2004;38(3):269–75. [PubMed: 14766108]

24. Flieger SP, Thomas CP, Prottas J. Improving Interorganizational Coordination Between Primary Care and Oncology: Adapting a Chronic Care Management Model for Patients With Cancer. Med Care Res Rev. 2019;1077558719870699. [PubMed: 31462141]

25. Oeffinger KC, Fontham ET, Etzioni R, Herzig A, Michaelson JS, Shih YC, et al. Breast Cancer Screening for Women at Average Risk: 2015 Guideline Update From the American Cancer Society. JAMA. 2015;314(15):1599–614. [PubMed: 26501536]

26. Maxwell AJ, Clements K, Hilton B, Dodwell DJ, Evans A, Kearins O, et al. Risk factors for the development of invasive cancer in unresected ductal carcinoma in situ. Eur J Surg Oncol. 2018;44(4):429–35. [PubMed: 29398324]

27. Smith RA, Andrews KS, Brooks D, Fedewa SA, Manassaram-Baptiste D, Saslow D, et al. Cancer screening in the United States, 2019: A review of current American Cancer Society guidelines and current issues in cancer screening. CA Cancer J Clin. 2019.

28. Press R, Carrasquillo O, Sciacca RR, Giardina EG. Racial/ethnic disparities in time to follow-up after an abnormal mammogram. J Womens Health (Larchmt). 2008;17(6):923–30. [PubMed: 18554094]

29. Hieman H, Artiga S. Beyond Health Care: The Role of Social Determinants in Promoting Health and Health Equity. Menlo Park, CA: Henry J. Kaiser Family Foundation; 2015.

30. Sabatino SA, Coates RJ, Uhler RJ, Breen N, Tangka F, Shaw KM. Disparities in mammography use among US women aged 40–64 years, by race, ethnicity, income, and health insurance status, 1993 and 2005. Med Care. 2008;46(7):692–700. [PubMed: 18580388]

31. Kranz AM, Dalton S, Damberg C, Timbie JW. Using Health IT to Coordinate Care and Improve Quality in Safety-Net Clinics. Jt Comm J Qual Patient Saf. 2018;44(12):731–40. [PubMed: 30064959]

32. Powell JL, Hawley JR, Lipari AM, Yildiz VO, Erdal BS, Carkaci S. Impact of the Addition of Digital Breast Tomosynthesis (DBT) to Standard 2D Digital Screening Mammography on the Rates of Patient Recall, Cancer Detection, and Recommendations for Short-term Follow-up. Acad Radiol. 2017;24(3):302–7. [PubMed: 27919540]

33. Giess CS, Pourjabbar S, Ip IK, Lacson R, Alper E, Khorasani R. Comparing Diagnostic Performance of Digital Breast Tomosynthesis and Full-Field Digital Mammography in a Hybrid Screening Environment. AJR Am J Roentgenol. 2017;209(4):929–34. [PubMed: 28639832]
### Take-Home Points:

- Optimal follow-up of women assessed to have BI-RADS 3 breast imaging findings occur in only 74% of cases but adherence is influenced by patient factors.

- Social determinants of health, including lack of insurance coverage, younger age, divorced status and Hispanic ethnicity are associated with lack of optimal follow-up for BI-RADS 3 breast imaging findings.

- There is optimal follow-up in patients seen by referring providers at a cancer institute. Factors that facilitate care coordination in such sites likely enhance patient follow-up care.
Table 1:
Univariate analysis of patient- and provider-related factors on optimal follow-up of BI-RADS 3 breast findings (n=1,586)

| Factors                  | Optimal Follow-up n=1,125 (%) | Late or No Follow-up n=386 (%) | Odds Ratio (95% CI) |
|--------------------------|-------------------------------|-------------------------------|---------------------|
| Age (mean)               | 52 (49)                       |                               | 1.02 (1.01–1.03) *  |
| **Race**                 |                               |                               |                     |
| White                    | 797 (70.8)                    | 259 (67.1)                    | Reference           |
| African-American         | 105 (9.3)                     | 40 (10.4)                     | 0.85 (0.58–1.27)    |
| Asian                    | 58 (5.1)                      | 12 (3.1)                      | 1.57 (0.86–3.11)    |
| Hispanic                 | 92 (8.1)                      | 47 (12.2)                     | 0.64 (0.44–0.94) *  |
| Other                    | 73 (6.5)                      | 28 (7.3)                      | 0.85 (0.54–1.36)    |
| **Insurance Status**     |                               |                               |                     |
| Private                  | 765 (68.0)                    | 217 (56.2)                    | Reference           |
| Public                   | 197 (17.5)                    | 65 (16.8)                     | 0.86 (0.63–1.18)    |
| None                     | 163 (14.5)                    | 104 (26.9)                    | 0.45 (0.33–0.59) *  |
| **Marital Status**       |                               |                               |                     |
| Married                  | 707 (62.8)                    | 208 (53.9)                    | Reference           |
| Single                   | 270 (24.0)                    | 113 (29.3)                    | 0.70 (0.54–0.92) *  |
| Divorced                 | 60 (5.3)                      | 33 (8.5)                      | 0.54 (0.34–0.84) *  |
| Other                    | 88 (7.6)                      | 32 (8.3)                      | 0.81 (0.53–1.25)    |
| **Prior breast cancer**  |                               |                               |                     |
| Prior other cancer       | 152 (13.5)                    | 30 (7.8)                      | 0.54 (0.36–0.82) *  |
| **Provider site**        |                               |                               |                     |
| Academic medical center  | 668 (59.3)                    | 245 (63.5)                    | Reference           |
| Community teaching hospital | 32 (2.8)                | 12 (3.1)                      | 0.98 (0.45–1.93)    |
| Cancer institute         | 53 (4.7)                      | 7 (1.8)                       | 2.76 (1.25–6.19) *  |
| Outpatient facilities    | 152 (13.5)                    | 43 (11.1)                     | 1.29 (0.89–1.86)    |
| Unaffiliated             | 191 (16.9)                    | 59 (15.3)                     | 1.18 (0.85–1.65)    |
| Other                    | 29 (2.5)                      | 20 (5.2)                      | 0.53 (0.29–0.96) *  |
| **Provider specialty**   |                               |                               |                     |
| Medicine                 | 615 (54.7)                    | 219 (55.7)                    | Reference           |
| OB-GYN                   | 168 (14.9)                    | 55 (14.2)                     | 1.09 (0.77–1.53)    |
| Surgery                  | 90 (8.0)                      | 34 (8.8)                      | 0.94 (0.62–1.44)    |
| Other                    | 252 (22.4)                    | 78 (20.2)                     | 1.15 (0.86–1.55)    |
| **Modality**             |                               |                               |                     |
| Mammography              | 955 (84.9)                    | 281 (72.8)                    | Reference           |
| Ultrasound               | 170 (15.1)                    | 105 (27.2)                    | 0.48 (0.36–0.63) *  |
| **Breast Density**       |                               |                               |                     |
| Factors  | Optimal Follow-up n=1,125 (%) | Late or No Follow-up n=386 (%) | Odds Ratio (95% CI) |
|----------|-----------------------------|-------------------------------|-------------------|
| Dense    | 240 (21.3)                  | 75 (19.4)                     | 1.05 (0.72–1.52)  |

* Statistically Significant
Table 2:
Multivariable analysis of patient- and provider-related factors on optimal follow-up of BI-RADS 3 breast findings

| Effect              | Odds Ratio | 95% Confidence Interval |
|---------------------|------------|-------------------------|
| Age                 | 1.011 *    | 1.000 1.021             |
| Race                |            |                         |
| White               | Reference  |                         |
| Asian               | 2.249 *    | 1.193 4.581             |
| African-American    | 0.864      | 0.574 1.322             |
| Hispanic            | 0.645 *    | 0.430 0.975             |
| Other               | 1.022      | 0.637 1.684             |
| Marital Status      |            |                         |
| Married             | Reference  |                         |
| Divorced            | 0.527 *    | 0.331 0.849             |
| Unknown             | 0.863      | 0.552 1.377             |
| Single              | 0.916      | 0.680 1.239             |
| Insurance Status    |            |                         |
| Private             | Reference  |                         |
| Public              | 0.816      | 0.567 1.183             |
| None                | 0.503 *    | 0.368 0.689             |
| Provider Site       |            |                         |
| Academic medical center | Reference     |                         |
| Community teaching hospital | 1.253   | 0.624 2.676             |
| Cancer institute    | 4.925 *    | 1.698 15.696            |
| Other               | 0.535      | 0.288 1.013             |
| Outpatient facilities| 1.442      | 0.952 2.217             |
| Unaffiliated        | 2.159      | 0.956 4.889             |
| Provider Specialty  |            |                         |
| Medicine            | Reference  |                         |
| OB-GYN              | 0.998      | 0.677 1.484             |
| Surgery             | 1.058      | 0.668 1.706             |
| Unaffiliated        | 0.535      | 0.248 1.154             |
| Cancer              |            |                         |
| Prior breast cancer | 1.685 *    | 1.022 2.779             |
| Prior other cancer  | 0.754      | 0.546 1.041             |
| Modality            |            |                         |
| Mammography         | Reference  |                         |
| Ultrasound          | 0.550 *    | 0.400 0.758             |

* Statistically Significant