Published in final edited form as:

J Am Coll Radiol. 2017 February ; 14(2): 198–207.e2. doi:10.1016/j.jacr.2016.08.017.

Challenges with identifying indication for exam in breast imaging as a key clinical attribute in practice, research, and policy

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Abstract

Purpose—To assess indication for exam for four breast imaging modalities and describe the complexity and heterogeneity of data sources and ascertainment methods.

Methods—Indication was evaluated among the Population-based Research Optimizing Screening through Personalized Regimens (PROSPR) breast cancer research centers (PRCs).

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Conflicts of interest: All authors have no conflicts of interest related to the material presented in this manuscript.

Indication data was reported overall and separately for four breast imaging modalities – digital mammography (DM), digital breast tomosynthesis (DBT), ultrasound (US) and magnetic resonance imaging (MRI).

Results—The breast PRCs contributed 236,262 women with 607,735 breast imaging records from 31 radiology facilities. We found a high degree of heterogeneity for indication within and across 6 data sources. Structured codes within a data source were used most often to identify indication for mammography (59% DM, 85% DBT) and text analytics for US (45%) and MRI (44%). Indication could not be identified for 17% of US and 26% of MRI compared to 2% of mammography exams (1% DM, 3% DBT).

Conclusion—Multiple and diverse data sources, heterogeneity of ascertainment methods and non-standardization of codes within and across data systems for determining indication were found. Consideration of data sources and standardized methodology for determining indication is needed to assure accurate measurement of cancer screening rates and performance in clinical practice and research.

Introduction

Indication for exam is a key clinical attribute used to differentiate screening exams (for asymptomatic patients) from diagnostic exams (for patients with symptoms or needing additional work up) to measure cancer screening rates, provider performance, and to optimize clinical care and resource use.(1, 2) Four primary imaging modalities are currently used for both breast cancer screening and diagnostic exams: digital mammography (DM), digital breast tomosynthesis (DBT), ultrasound (US), and breast magnetic resonance imaging (MRI). When evaluating these modalities, it is important to be able to determine if the purpose (indication) of an exam was for cancer screening or for diagnosis of a problem. Indication influences the imaging protocol used for each of the above imaging modalities and may change the radiologist's pre-test probability of finding pathology (3, 4). Therefore, performance outcomes (sensitivity, specificity, positive predictive value, and cancer detection rate) are all dependent on indication.

Accurate categorization of indication has implications for research and clinical practice. Both research and clinical domains share the common need for measurement - such as imaging performance measures and screening rates - that ultimately inform national policies regarding recommendations and guidelines (5). The American College of Radiology (ACR) requires incorporating the indication to establish benchmarks and best practices.(6) Screening US is increasingly performed for dense breast tissue (7) as well as for some women with moderately elevated lifetime cancer risk.(8) Evaluation of screening US should be different from that performed for diagnostic purposes (complete or targeted).(9) (10) (11) However, Current Procedure Terminology (CPT) codes found in billing claims for breast US and MRI do not permit discrimination between screening and diagnostic indications.

Indication data are captured using a variety of sources including clinical data systems, billing codes, medical records and patient intake forms. For example, radiology information systems (RIS) are routinely used in clinical practice and contain data related to specific exams. Additionally, clinical notes – typically in text format – may capture indication.

Furthermore, validated algorithms using CPT codes found in Medicare claims have been developed to determine indication for mammography, but not for other imaging modalities (12, 13).

The objectives of this study were to 1) identify the data sources and indication ascertainment methods used across different health care settings with multiple facilities using a variety of clinical data systems; 2) describe the heterogeneity and complexity of indication ascertainment; and 3) report indication data by imaging modality (DM, DBT, US and MRI). Understanding indication data sources and ascertainment will provide insight into developing consensus on standardized algorithms and inform strategies to ensure the integrity of utilization of clinical data for quality research and clinical practice.

Methods

Study Population and Setting

This study was conducted as part of the National Cancer Institute (NCI)-funded consortium Population-based Research Optimizing Screening through Personalized Regimens (PROSPR). The overall aim of PROSPR is to conduct multi-site, coordinated, transdisciplinary research to evaluate and improve cancer screening processes. The PROSPR Research Centers (PRCs) reflect the diversity of United States delivery system organizations. Data used were from women undergoing breast imaging at a facility affiliated with three breast PRCs: 1) Dartmouth-Hitchcock (DH) health in the state of New Hampshire and Brigham and Women's Hospital (BWH) and affiliated practices in the state of Massachusetts, 2) the University of Pennsylvania (UPenn) located in Philadelphia, Pennsylvania and 3) the Vermont Breast Cancer Surveillance System (VT) in Burlington, Vermont. Data were submitted to PROSPR's Statistical Coordinating Center (SCC) in September 2015.

Our descriptive study was based on a systematic review of processes used by three breast PRCs for mapping clinical data to the defined SCC indication data element. This project involved the PROSPR breast study population of those individuals who are associated with clinical provider networks eligible for screening. We described the complexity of capturing and mapping indication from a variety of data sources and systems to determine if there are common keyword(s)/terms/codes that may characterize indication and assessed if the process and/or data used for capturing indication was global, efficient and standardized.

The PROSPR cohort inclusion criteria and settings differed by PRC. DH-BWH included women between the ages of 30–89 years with a qualifying primary care visit within Brigham and Women's Primary Care Practice-Based Research Network or within Dartmouth-Hitchcock health starting on January 1, 2011 through September 30, 2014. DH-BWH PRC was comprised of 25 primary care facilities (DH: 9; BWH: 16) and 10 radiology imaging facilities (DH: 3; BWH: 7). UPenn's inclusion criteria included women between 18–89 years of age with a breast cancer screening exam at one of their seven radiology imaging facilities, or women ages 21–89 years of age at the time of their first primary care or obstetrics/gynecology practice visit on or after January 1, 2012 until December 31, 2013.

VT PRC included women 18–89 years of age with at least one imaging exam at one of their 14 radiology facilities beginning January 1, 2011 through September 30, 2014.

Definitions and Analysis

The SCC provided a data dictionary to each breast PRC with common data elements and instructions detailing the structure for individual records. The SCC's definition for indication was informed by the Breast Cancer Surveillance Consortium(14) and the National Mammography Database.(15) indication was defined with categorical values: (1) Routine screening, (2) Additional evaluation of recent procedure, (3) Short interval follow-up, (4) Evaluation of a symptomatic breast problem, (5) Cancer staging, treatment, or monitoring, (95) Other, (98) Not applicable, and (99) Unknown. A separate record per woman per breast imaging event (or imaging combination) was generated for each Breast Imaging-Reporting and Data System (BI-RADS) assessment.(16) PRCs reported the most severe indication if there were multiple records on the same day. The order of indication severity was defined as: (5) Cancer staging, treatment, or monitoring, (4) Evaluation of a symptomatic breast problem, (3) Short interval follow-up, (2) Additional evaluation of recent procedure, (95) Other, and (1) Routine screening. The breast PRCs captured and mapped indication from multiple, diverse data systems. The discrete diagnostic indication categories varied by PRC; DH mapped all diagnostic exams to an indication of (4) Evaluation of a symptomatic breast problem, while all UPenn diagnostic exams were mapped to an indication of: (2) Additional evaluation of recent procedure. Both VT and BWH were able to differentiate diagnostic studies into all of the diagnostic indication categories. For the purpose of evaluating screening and diagnostic exams, we collapsed the diagnostic values of indication, (2) through (5), into a single category of *diagnostic*. Additionally, we grouped the categories of other (95), not applicable (98) and unknown (99) as *unknown*.

To obtain uniform information about indication capture at each PRC, we developed a detailed semi-structured interview template from which we conducted in-person interviews with each data manager between February-July 2014. The interview template covered the following domains: 1) data systems and sources, 2) data flow from sources to delivery, and 3) data processes specifying strategies and algorithms. Information was collected on whether the PRC's indication data was retrieved from individual or combinations of systems involving electronic record capture (e.g., electronic health record (EHR), stand-alone departmental systems, billing, scheduling, or ordering systems) or manual record capture (e.g., paper forms such as radiology technical reports, patient self-report questionnaires or medical record abstraction from a clinical intake form). Key characteristics about indication capture such as documentation, data formats, number of imaging facilities, keywords, terms and codes, logic, and decisions for mapping data to PROSPR indication values were collected. We assessed and categorized data sources and indication ascertainment methods from the completed PRC interviews. A data flow diagram was created for each PRC. We reported the indication frequency distributions by breast imaging modality and PRC.

After identifying the data sources, we categorized the methods of ascertainment into three groups: *Code Classification*, *Text Analytics*, and *Temporal Algorithm*. ***Code Classification*** indicates that an exam code was used to determine indication. These codes can be internal to

the institution such as within an EHR, as structured codes within data sources such as a RIS system, or CPT codes from claims within a billing system. *Text analytics* includes: 1) a manual process involving data collected by standardized forms or record review abstraction or 2) a program that utilizes a simple key word search or a more sophisticated application of natural language processing to determine the indication. *Temporal algorithm* accounts for when the image was performed relative to key events such as an initial screen, biopsy, diagnosis of cancer, or context based on initial BI-RADS to determine the indication categorization.

Results

The population of women from the three breast PRCs totaled 236,262 women with 607,735 breast imaging records from 31 radiology facilities (Table 1). Figure 1 illustrates each breast PRC's data flow from data sources to the number of breast imaging records submitted to the PROSPR imaging database. Each breast PRC differed in types and number of data sources. For the DH-BWH PRC, 4 data sources of RIS, EHR, ordering system and billing were utilized for capturing breast imaging exams into two separate databases and then combined into a single database. UPenn accessed a single RIS system from which indication was extracted into their database. VT's database combined information from EHRs, radiology intake forms and by programmatic abstraction from radiology reports. Final exports of breast imaging data to the PROSPR database numbered 171,277 for DH-BWH, 95,584 for UPenn and 340,874 for VT. Among PRCs, six data sources were identified for extracting indication for DM, DBT, US and MRI exams. Figure 1 depicts the data sources and flow for capturing and ascertaining indication for each PRC including: 1) provider ordering system, 2) RIS, 3) EHR, 4) radiology intake forms, 5) radiology reports and 6) billing system (claims data). The majority of indication captured (80% across the PRCs) was through the RIS (range: 72% to 100%). Three different commercial RIS were used, with the systems differing by versions and releases, resulting in substantial variation in indication codes and text fields (Appendix A).

Figure 2 addresses the interaction of the patient, provider, breast indication determination process and the six data sources (depicted in pink) used by the breast PRCs for capturing and ascertaining indication. The indication determination is an iterative process and in the case of breast imaging, depends on the interaction between the provider and woman and whether the woman indicates having symptoms at the time of scheduling or responds that she is symptomatic on the radiology intake form; prompting a change in indication. Consequently, the dependence on the timing of indication extraction may impact the choice of data source for extraction.

The results of the indication classification (screening, diagnostic and unknown) by breast imaging modality are shown in Table 2. Overall, 74% of breast imaging records were screening, followed by 23% diagnostic and 3% unknown. Screening was dominated by mammography (81% DM and 83% DBT) while 2% of US and 31% MRI were categorized as screening. Diagnostic imaging records were the highest among US (82%) followed by MRI (42%). Unknown indication of 17% for US and 26% for MRI compared to 1% for DM and 3% DBT were found. In addition, to illustrate heterogeneity, ascertainment methods are

presented by PRC for each breast imaging modality (Table 2). A result of not applicable (NA) indicated that the PRC did not use the specific method of ascertainment for determining indication.

Comparisons of the methods of ascertainment by indication (screening, diagnostic and unknown) for each breast imaging modality are shown in Figure 3. Code classification was used most often to identify indication for mammography (59% DM, 85% DBT), with screening mammography being the highest (53% DM, 78% DBT). Text analytics was used most often to ascertain indication for US (45%) and MRI (44%). For mammography, text analytics was found to be nearly four times more likely to be used for DM than DBT (38% vs. 10%). All 3 ascertainment methods were used for diagnostic exams regardless of breast imaging modality. 12% of US and 19% of MRI used the temporal algorithm compared to 3% DM and 6% DBT.

Discussion

Complete and accurate categorization of indication is critical to delivering optimal care to individuals and populations, to quality improvement, and to the development of evidence on the comparative effectiveness of different screening modalities and diagnostic algorithms. We documented variation in indication categorization by breast imaging modality and data source and found little standardization in coding, text fields and methods of ascertainment. While indication could be identified for almost all mammograms, indication could not be determined for a substantial number of US and MRI exams. The high percentage of unknown indication for breast ultrasound and MRI is particularly problematic for research, as precision use of these modalities is still being determined.

Accurate identification of indication is important to the delivery of high quality clinical care, quality initiatives, research, and our understanding of health policy related to screening and diagnostic evaluation. In clinical care, indication may influence timeliness of scheduling, imaging protocol, and interpretation.(17) Incorrect categorization of indication may contribute to delays in care, inappropriate care, and false-negative and false-positive results. In 2013, the American College of Radiology recommended that separate audit statistics should be maintained for screening and diagnostic examinations of all modalities because certain quality benchmarks, such as the cancer detection rate, is calculated for screening exams.(18) The Institute of Medicine also recommends the utilization of separate performance measures for screening and diagnostic imaging.(19) The development and diffusion of new imaging modalities, like DBT, requires comparative effectiveness analyses in clinical practice to inform the appropriate use of these technologies.(20–22) From a policy perspective, accurate assessment of screening versus diagnostic indication is needed to assess evidence-based use and equitable access.(23) While the Affordable Care Act has expanded coverage for screening exams in the U.S., these plans may not cover subsequent diagnostic evaluations. (24, 25) Understanding the impact of this policy is necessary for timely diagnostic evaluation. Similarly, the recent passage of breast density reporting legislation in many states,(26) highlights the need to accurately categorize indication to understand which women undergo supplementary screening with US or MRI.(27, 28)

Correctly identifying indication is also important for other cancers such as colorectal and lung. (29, 30) (31–33) Singal et al. addressed the challenges of defining indication, as screening, surveillance or diagnostic, given misclassification and ascertaining indication in colonoscopy.(34) Colonoscopy has an additional indication category of surveillance for which colonoscopy quality indicators for screening differ from surveillance.(35) Fassil et al. emphasized the importance of obtaining accurate indication from medical records to provide unbiased estimates for colon quality indicators and the effectiveness of screening colonoscopy.(36, 37) In mammography, the use of Medicare claims as a data source in validated algorithms has seen improvements in the ability to distinguish screening from diagnostic mammograms in claim's data (38) (39); however, there is still a need for the development of similar algorithms to determine indication for other breast imaging modalities.

Our investigation of indication for breast imaging found substantial heterogeneity of data sources and methods of ascertainment. While indication could be most easily identified for screening mammograms (DM and DBT), we found a more complex process was needed, and all three ascertainment methods were used to determine indication for diagnostic exams. With regards to data sources, 80% of indication was captured by radiology information systems. However, there were several commercial RISs utilized by the 3 PRCs varying in versions during the study period, namely, GE-RIS-Centricity version 10.8 UP7, GE-RIS-Centricity version 10.8 UP6, Meditech Magic 5.4 Service Release 2 and 3, Magview version 6.8.52 and IDXrad™ version 9.4. Presently, these RISs do not contain a single unique standardized field for indication.

Given our findings of multiple and diverse data sources, heterogeneity of ascertainment methods, and non-standardization of codes within and across data systems, the development of an indication lexicon with 3 levels – screening, surveillance and diagnostic – would greatly advance common definitions. The 3 levels are suggested for trans-organ comparisons. In addition to creating a lexicon, the 3-level indication would need to be implemented consistently, ideally in a single data source. As a single data source is unlikely across institutions, this lexicon would need to be implemented from scheduling systems to billing. However, the RIS data source would be a valuable and ideal single data source to standardize indication as its own unique field. We also found that code classification was the most efficient way to capture indication. Therefore, the combination of a unique indication field with standardized coding across different commercial RISs may be the most efficient means of identification of indication in a data source and by ascertainment method.

Standardization of indication across health care settings is a key avenue for producing comparable, generalizable, and reproducible data. Once the lexicon is established, indication categorization could be advanced through the use of standardized codes, formatted drop down menus in radiology ordering software, and the definition and use of standardized key words or phrases. Since the timing of indication extraction may impact the choice of a data source, billing or claims data may serve as a reliable data source since it is post-changes to indication and would be a common source for all imaging or procedures that require indication. However, billing codes are specific to the type of imaging modality or procedure and are not necessarily designed for identifying indication – as in the case of breast US or

MRI CPT codes which are insufficient for determining indication. Therefore, the creation of a 3-level indication specific modifier for claims data could be developed. Implementing a uniform 3-level indication across organ groups (i.e., for colorectal and other cancers in addition to breast) and within data sources would simplify and harmonize indication data extraction for all cancers to promote appropriate clinical management, identify quality issues, and promote research on effective care delivery.

The identification of indication is essential for establishing congruence and integrity of information related to clinical practice, research, and policy. Our findings suggest that the high degree of heterogeneity and complexity of data collection of indication for breast imaging is an issue, especially with breast MRI and ultrasound. Consideration of data sources and standardized methodology for indication is needed to assure accurate measurement of cancer screening rates and performance.

Acknowledgments

Funding: This project was supported by award number U54CA163307, U54CA163313, U54CA163303 and U01CA163304 from the National Cancer Institute (NCI) Population-based Research Optimizing Screening through Personalized Regimens (PROSPR) initiative.

The authors thank the participating PROSPR Research Centers for the data they have provided for this study. A list of the PROSPR investigators and contributing research staff is provided at: <http://healthcaredelivery.cancer.gov/prospr/>

Appendix A

Sample code descriptions and categorization of indication for exam by breast imaging modality and ascertainment method

Digital Mammography		
Ascertainment Method	Description or Exam Type	Indication for Exam
Code Classification	Mammo Digital Bilat Screening With CAD	1 (Routine Screening)
Code Classification	Mammo Digital Bilat screening with Lateral and CAD	1 (Routine Screening)
Code Classification	MAMMO UNILAT DIR DIGITAL MAMMO	4 (Evaluation of breast problem)
Code Classification	Mammo Digital Left Diag with CAD	4 (Evaluation of breast problem)
Code Classification	screen dig mammo bi all view	1 (Routine Screening)
Code Classification	dig screening mamm bil w/cad	1 (Routine Screening)
Code Classification	MASD: Digital Screening Mammogram	1 (Routine Screening)
Code Classification	bic025: G0202-SCREENING DIGITAL	1 (Routine Screening)

	MAMMO, BILAT	
Code Classification	MGSBZ: MAMMO BREAST SCREENING BILATERAL	1 (Routine Screening)
Code Classification	BIGGMAMRT	2=Additional Evaluation of Recent Procedure
Text Analytics	Asymptomatic	1 (Routine Screening)
Text Analytics	Screening	1 (Routine Screening)
Text Analytics	Screening (asymptomatic)	1=Routine Screening
Temporal Algorithm	BIGGMAMRT and Cat6 Assessment	9=Cancer staging, treatment, or monitoring
Temporal Algorithm	MABD: mammogram bilat digital	2 (Additional Evaluation) IF within temporal context of callback from screen
Temporal Algorithm	MALD: Digital Unilateral -Left Mammogram	2 (Additional Evaluation) IF within temporal context of callback from screen
Digital Breast Tomosynthesis		
Ascertainment Method	Description or Exam Type	Indication for Exam
Code Classification	Mam Digital Right Unilateral Screening w/CAD and Tomo	1 (Routine Screening)
Code Classification	MAM DIGITAL BILAT DIAG W/ IMPLANTS AND TOMO AND CAD	4 (Evaluation of breast problem)
Code Classification	Mammo Digital Bilateral Diagnostic With CAD and Tomosynthesis	4 (Evaluation of breast problem)
Code Classification	MASDT: Mammogram Screening Digital Tomo	1 (Routine Screening)
Code Classification	A	2=Additional Evaluation of Recent Procedure
Code Classification	Clinical Finding	4=Evaluation of breast problem (symptomatic)
Code Classification	BI SCREENING TOMO BILATERAL	1 (Routine Screening)
Code Classification	Digital Screen BI Mammo w/Tomo	1 (Routine Screening)
Text analytics	Additional Evaluation of a recent mammogram	2=Additional Evaluation of Recent Procedure
Temporal Algorithm	MABDT: Mammogram Bilateral Digital Tomo	2 (Additional Evaluation) IF within temporal context of callback from screen
Temporal Algorithm	MALDT: Mammogram Uni/Left Digital Tomo	2 (Additional Evaluation) IF within temporal context of callback from screen
Ultrasound		

Ascertainment Method	Description or Exam Type	Indication for Exam
Code Classification	History of breast augmentation, asymptomatic	1=Routine Screening
Text Analytics	Manual Abstraction of Report Text	
Text Analytics	Due for short interval follow up recommended by radiologist	3 (Short interval follow-up)
Text Analytics	Short interval followup	3=Short interval follow-up
Text Analytics + Temporal	Known biopsy proven malignancy and Biopsy <6 Months ago	3=Short interval follow-up
Temporal Algorithm	USBRST: Ultrasound Breast	2 (Additional Evaluation) IF within temporal context of callback from screen
Temporal Algorithm	bic021: 76645 Unil Ultrasound - Left	2 (Additional Evaluation) IF within temporal context of callback from screen
Magnetic Resonance Imaging		
Ascertainment Method	Description or Exam Type	Indication for Exam
Code Classification	MBRSTBIWOW	1=Routine Screening
Code Classification	History of benign breast biopsy	1=Routine Screening
Text Analytics	Manual Abstraction of Report Text	
Text Analytics	Evaluation of a breast problem (symptomatic)	4=Evaluation of breast problem (symptomatic)
Temporal Algorithm	USBRST: Ultrasound Breast	2 (Additional Evaluation) IF within temporal context of callback from screen
Temporal Algorithm	bic021: 76645 Unil Ultrasound - Left	2 (Additional Evaluation) IF within temporal context of callback from screen

References

1. Feig SA. Auditing and benchmarks in screening and diagnostic mammography. Radiologic clinics of North America. 2007; 45(5):791–800. vi. [PubMed: 17888769]
2. de la Cruz MS, Sarfaty M, Wender RC. An update on breast cancer screening and prevention. Primary care. 2014; 41(2):283–306. [PubMed: 24830609]
3. Sickles EA, Miglioretti DL, Ballard-Barbash R, Geller BM, Leung JW, Rosenberg RD, et al. Performance benchmarks for diagnostic mammography. Radiology. 2005; 235(3):775–790. [PubMed: 15914475]
4. Geller BM, Barlow WE, Ballard-Barbash R, Ernster VL, Yankaskas BC, Sickles EA, et al. Use of the American College of Radiology BI-RADS to report on the mammographic evaluation of women with signs and symptoms of breast disease. Radiology. 2002; 222(2):536–542. [PubMed: 11818625]
5. Lee CH, Dershaw DD, Kopans D, Evans P, Monsees B, Monticciolo D, et al. Breast cancer screening with imaging: recommendations from the Society of Breast Imaging and the ACR on the use of mammography, breast MRI, breast ultrasound, and other technologies for the detection of

- clinically occult breast cancer. *Journal of the American College of Radiology : JACR*. 2010; 7(1): 18–27. [PubMed: 20129267]
6. [accessed January, 2016] <http://www.acr.org/~media/ACR/Documents/Accreditation/BICOE/BICOErequirements.pdf>.
 7. Corsetti V, Houssami N, Ghirardi M, Ferrari A, Speziani M, Bellarosa S, et al. Evidence of the effect of adjunct ultrasound screening in women with mammography-negative dense breasts: interval breast cancers at 1 year follow-up. *European journal of cancer*. 2011; 47(7):1021–1026. [PubMed: 21211962]
 8. Berg WA, Blume JD, Cormack JB, Mendelson EB, Lehrer D, Bohm-Velez M, et al. Combined screening with ultrasound and mammography vs mammography alone in women at elevated risk of breast cancer. *JAMA : the journal of the American Medical Association*. 2008; 299(18):2151–2163. [PubMed: 18477782]
 9. Sickles EA, D'Orsi CJ. How should screening breast US be audited? The BI-RADS perspective. *Radiology*. 2014; 272(2):316–320. [PubMed: 25058131]
 10. Hooley RJ, Scoutt LM, Philpotts LE. Breast ultrasonography: state of the art. *Radiology*. 2013; 268(3):642–659. [PubMed: 23970509]
 11. Brem RF. Screening whole breast ultrasound: an opportunity to move to personalized, effective breast cancer screening. *The breast journal*. 2012; 18(6):515–516. [PubMed: 23127116]
 12. Smith-Bindman R, Quale C, Chu PW, Rosenberg R, Kerlikowske K. Can Medicare billing claims data be used to assess mammography utilization among women ages 65 and older? *Medical care*. 2006; 44(5):463–470. [PubMed: 16641665]
 13. Fenton JJ, Onega T, Zhu W, Balch S, Smith-Bindman R, Henderson L, et al. Validation of a Medicare Claims-based Algorithm for Identifying Breast Cancers Detected at Screening Mammography. *Medical care*. 2013
 14. Ballard-Barbash R, Taplin SH, Yankaskas BC, Ernster VL, Rosenberg RD, Carney PA, et al. Breast Cancer Surveillance Consortium: a national mammography screening and outcomes database. *AJR American journal of roentgenology*. 1997; 169(4):1001–1008. [PubMed: 9308451]
 15. Osuch JR, Anthony M, Bassett LW, DeBor M, D'Orsi C, Hendrick RE, et al. A proposal for a national mammography database: content, purpose, and value. *AJR American journal of roentgenology*. 1995; 164(6):1329–1334. discussion 35-6. [PubMed: 7754870]
 16. D'Orsi CJSE, Mendelson EB, Morris EA, et al. *ACR BI-RADS® Atlas, Breast Imaging Reporting and Data System*. ACR BI-RADS® Atlas, Breast Imaging Reporting and Data System. 2013
 17. Lee CI, Ichikawa L, Rochelle MC, Kerlikowske K, Miglioretti DL, Sprague BL, et al. Breast MRI BI-RADS assessments and abnormal interpretation rates by clinical indication in US community practices. *Academic radiology*. 2014; 21(11):1370–1376. [PubMed: 25126973]
 18. Sickles E, D'Orsi CJ. *ACR BI-RADS® Follow-up and Outcome Monitoring*. ACR BI-RADS® Atlas, Breast Imaging Reporting and Data System Reston, VA, American College of Radiology. 2013
 19. Nass S, Ball J. Improving breast imaging quality standards. Committee on Improving Mammography Quality Standards, National Research Council. 2005
 20. Friedewald SM, Rafferty EA, Conant EF. Breast cancer screening with tomosynthesis and digital mammography-reply. *JAMA : the journal of the American Medical Association*. 2014; 312(16): 1695–1696.
 21. McCarthy AM, Kontos D, Synnestvedt M, Tan KS, Heitjan DF, Schnall M, et al. Screening outcomes following implementation of digital breast tomosynthesis in a general-population screening program. *Journal of the National Cancer Institute*. 2014; 106(11)
 22. McDonald ES, McCarthy AM, Akhtar AL, Synnestvedt MB, Schnall M, Conant EF. Baseline Screening Mammography: Performance of Full-Field Digital Mammography Versus Digital Breast Tomosynthesis. *AJR American journal of roentgenology*. 2015; 205(5):1143–1148. [PubMed: 26496565]
 23. Harvey SC, Vegesna A, Mass S, Clarke J, Skoufalos A. Understanding patient options, utilization patterns, and burdens associated with breast cancer screening. *Journal of women's health*. 2014; 23(Suppl 1):S3–S9.

24. [accessed February, 2016] <http://www.cancer.org/cancer/breastcancer/moreinformation/breastcancerearlydetection/breast-cancer-early-detection-paying-for-br-ca-screening>.
25. [accessed February, 2016] <http://nwlc.org/resources/women%E2%80%99s-preventive-services-affordable-care-act-frequently-asked-questions/#fact%20sheet>.
26. Smith ML. The density conundrum: does legislation help or hurt? *Journal of the American College of Radiology : JACR*. 2013; 10(12):909–912. [PubMed: 24295939]
27. Sprague BL, Gangnon RE, Burt V, Trentham-Dietz A, Hampton JM, Wellman RD, et al. Prevalence of mammographically dense breasts in the United States. *Journal of the National Cancer Institute*. 2014; 106(10)
28. Suzuki A, Ishida T, Ohuchi N. Controversies in breast cancer screening for women aged 40–49 years. *Japanese journal of clinical oncology*. 2014; 44(7):613–618. [PubMed: 24821976]
29. Moyer V. Lung cancer prevention and screening. *Oncology (Williston Park)*. 2014; 28(5):449–450. [PubMed: 25004663]
30. Moyer VA. Force USPST. Screening for lung cancer: U.S. Preventive Services Task Force recommendation statement. *Annals of internal medicine*. 2014; 160(5):330–338. [PubMed: 24378917]
31. Volk RJ, Foxhall LE. Readiness of primary care clinicians to implement lung cancer screening programs. *Prev Med Rep*. 2015; 2:717–719. [PubMed: 26844142]
32. Volk RJ, Hawk E, Bevers TB. Should CMS cover lung cancer screening for the fully informed patient? *JAMA : the journal of the American Medical Association*. 2014; 312(12):1193–1194. [PubMed: 25247511]
33. Volk RJ, Linder SK, Leal VB, Rabius V, Cinciripini PM, Kamath GR, et al. Feasibility of a patient decision aid about lung cancer screening with low-dose computed tomography. *Prev Med*. 2014; 62:60–63. [PubMed: 24518006]
34. Singal AG, Gupta S, Lee J, Halm EA, Rutter CM, Corley D, et al. Importance of determining indication for colonoscopy: implications for practice and policy original. *Clinical gastroenterology and hepatology : the official clinical practice journal of the American Gastroenterological Association*. 2014; 12(12):1958–1963. e1–e3. [PubMed: 25606584]
35. Anderson JC, Butterly LF, Goodrich M, Robinson CM, Weiss JE. Differences in detection rates of adenomas and serrated polyps in screening versus surveillance colonoscopies, based on the new hampshire colonoscopy registry. *Clinical gastroenterology and hepatology : the official clinical practice journal of the American Gastroenterological Association*. 2013; 11(10):1308–1312. [PubMed: 23660415]
36. Fassil H, Adams KF, Weinmann S, Doria-Rose VP, Johnson E, Williams AE, et al. Approaches for classifying the indications for colonoscopy using detailed clinical data. *BMC cancer*. 2014; 14:95. [PubMed: 24529031]
37. 2016 <http://www.gastro.org/practice/coding/coding-faqs-screeningcolonoscopy> aJ.
38. Randolph WM, Mahnken JD, Goodwin JS, Freeman JL. Using Medicare data to estimate the prevalence of breast cancer screening in older women: comparison of different methods to identify screening mammograms. *Health services research*. 2002; 37(6):1643–1657. [PubMed: 12546290]
39. Fenton JJ, Zhu W, Balch S, Smith-Bindman R, Fishman P, Hubbard RA. Distinguishing screening from diagnostic mammograms using Medicare claims data. *Medical care*. 2014; 52(7):e44–e51. [PubMed: 22922433]

Summary Statement

Ascertainment of the indication for exam for breast imaging involves substantial heterogeneity of data sources and methodology. Lack of standardized capture of indication may be a potential issue, especially for breast MRI and ultrasound.

Fig 1. Indication for exam data flow among the breast cancer research centers affiliated with the Population-based Research Optimizing Screening for Personalized Regimens (PROSPR) consortium

Fig 2.

Points of indication for exam determination and extraction

Abbreviations: IFE= indication for exam; DM = digital mammography; DBT = digital breast tomosynthesis; US = ultrasound; MRI = magnetic resonance imaging.

Fig 3.

Percent of indication for exam extracted by ascertainment method for each breast imaging modality

Abbreviations: IFE = indication for exam; SCR = screening; DX = diagnostic; UK = unknown. Legend: **Code Classification** indicates an exam code was used to determine the indication for a given exam. **Text analytics** includes manual processes or programs that utilize simple key word searches or natural language processing to determine the indicator. **Temporal algorithm** incorporates when the image was performed relative to key events.

Table 1

Overview of the three PROSPR breast cancer research centers (PRCs)

PRC	Population of Women with Breast Imaging	Number of Breast Imaging Records	Number of Contributing Radiology Facilities
DH-BWH 2011–2014	67,283	171,277	10
VT 2011–2014	113,766	340,874	14
UPenn 2012–2013	55,213	95,584	7
Total	236,262	607,735	31

Table 2

Percent (%) of indication by breast imaging modality and % of PRC's indication ascertainment methods for each breast imaging modality

	Digital Mammography (N = 475,874)			Breast Tomosynthesis (N = 78,122)			Ultrasound (N = 47,499)			Magnetic Resonance Imaging (N = 6,240)		
	DH- BWH	UPenn	VT	DH- BWH	UPenn	VT	DH- BWH	UPenn	VT	DH- BWH	UPenn	VT
Number of Breast Images (N=607,735)	132,074	61,431	282,369	25,140	26,534	26,448	11,401	6,077	30,021	2,662	1,542	2,036
Indication (N ;%)	%	%	%	%	%	%	%	%	%	%	%	%
Screening (N=452,596; 74%)	81%			83%			2%			31%		
Code classification	78	88	34	74	85	77	NA	NA	1	NA	NA	35
Text analytics	3	NA	45	8	NA	6	3	NA	<1	11	55	38
Temporal algorithm	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Final Imputed indication	81	88	79	82	85	83	3	NA	1	11	55	72
Diagnostic (N=140,274; 23%)	18%			14%			82%			42%		
Code classification	6	NA	8	3	NA	14	NA	NA	48	NA	NA	12
Text analytics	13	NA	11	11	NA	1	47	NA	50	39	NA	14
Temporal algorithm	NA	8	2	NA	9	2	NA	66	<1	NA	27	2
Final Imputed indication	19	8	21	14	9	17	47	66	98	39	27	28
Unknown (N=14,865; 2%)	1%			3%			17%			26%		
Code classification	NA	0	<1	NA	NA	<1	46	NA	<1	38	NA	<1
Text analytics	NA	NA	<1	4	NA	NA	4	NA	<1	13	NA	<1
Temporal algorithm	NA	4	NA	NA	6	NA	NA	34	NA	NA	18	NA
Final Imputed indication	NA	4	<1	4	6	<1	50	34	<1	51	18	<1

Abbreviations: NA = not applicable