The Influence of Mammographic Technologists on Radiologists' Ability to Interpret Screening Mammograms in Community Practice

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Rationale and Objectives: To determine whether the mammographic technologist has an effect on the radiologists' interpretative performance of screening mammography in community practice.

Materials and Methods: In this institutional review board–approved retrospective cohort study, we included Carolina Mammography Registry data from 372 radiologists and 356 mammographic technologists from 1994 to 2009 who performed 1,003,276 screening mammograms. Measures of interpretative performance (recall rate, sensitivity, specificity, positive predictive value [PPV_1], and cancer detection rate [CDR]) were ascertained prospectively with cancer outcomes collected from the state cancer registry and pathology reports. To determine if the mammographic technologist influenced the radiologists' performance, we used mixed effects logistic regression models, including a radiologist-specific random effect and taking into account the clustering of examinations across women, separately for screen-film mammography (SFM) and full-field digital mammography (FFDM).

Results: Of the 356 mammographic technologists included, 343 performed 889,347 SFM examinations, 51 performed 113,929 FFDM examinations, and 38 performed both SFM and FFDM examinations. A total of 4328 cancers were reported for SFM and 564 cancers for FFDM. The technologists had a statistically significant effect on the radiologists' recall rate, sensitivity, specificity, and CDR for both SFM and FFDM (*P* values <.01). For PPV_1, variability by technologist was observed for SFM (*P* value <.0001) but not for FFDM (*P* value = .088).

Conclusions: The interpretative performance of radiologists in screening mammography varies substantially by the technologist performing the examination. Additional studies should aim to identify technologist characteristics that may explain this variation.

Key Words: Mammography; sensitivity and specificity; observer variation.

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Breast cancer is the most common cancer in women, excluding cancers of the skin and is expected to account for an estimated 232,670 cases and 40,000 deaths in the United States in 2014 (1). Routine screening mammography is the primary means of early breast cancer detection with radiologic technologists fulfilling an essential role in the mammography process. Although routine screening mammography has been shown to be effective in reducing breast cancer mortality (2), many factors lead to variability in interpretative performance by radiologists (3–6).

Several studies have found radiologists' gender, work patterns, postresidency training, years of experience, specialization, and screening versus diagnostic mix influence mammography performance measures (3,7–12). It is also likely that the radiologists' ability to interpret mammograms is affected by technologists who work with the radiologists. Possible sources of variation in radiologists' interpretative ability may include the interface between the radiologist and technologist and the ability of the radiologic technologist to obtain a high-quality image in terms of positioning, compression, and sharpness.

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Prior studies have examined the performance of technologists as prereaders or double readers of screening mammography in conjunction with radiologists. In general, the use of technologists as prereaders or double readers for screening mammograms led to increased cancer detection rates (CDRs) without significantly increased recall or false-positive rates (13–17). To our knowledge, no studies have examined the extent of variability among radiologists' screening mammography performance by the technologist performing the examination. Hence, we used 15 years of community-based mammography data to determine whether the performance characteristics of screening mammography differ by technologist for screen-film mammography (SFM) and full-field digital mammography (FFDM) separately.

MATERIALS AND METHODS

The Carolina Mammography Registry (CMR) has collected prospective data from mammography facilities in North Carolina since 1994. Information includes characteristics of women, reason for the breast-imaging visit, breast cancer risk factors, imaging procedures performed, radiologist's findings, assessments, and management recommendations. These data are linked with the state cancer registry and pathology data to allow for calculation of standard performance measures including recall rate, sensitivity, specificity, positive predictive value of recall (PPV_1), and CDR. For each mammogram performed at CMR participating facilities, a unique technologist code was collected. These technologist codes allow for the identification of technologists over time and across CMR participating facilities.

Study Population

The study included 1,012,491 bilateral screening mammograms among women aged ≥18 years, with no personal history of breast cancer and no breast implants, from CMR participating facilities, between January 1, 1994 and December 31, 2009. We excluded 9215 screening mammograms in which the technologist performed fewer than 50 examinations per year or were active for <6 months. This gave a total of 1,003,276 screening mammograms that were performed by 356 technologists, interpreted by 372 radiologists, and performed at 59 facilities.

Definitions

Using standard definitions, we defined a screening mammogram as a bilateral, two-view mammogram indicated as screening by the radiologist (18). Each mammogram interpretation was classified as positive or negative based on the radiologists' Breast Imaging Reporting and Data System (BI-RADS) screening assessment result. We defined an examination positive for recall if the initial BI-RADS assessment was 0 (additional imaging required), 4 (suspicious abnormality), 5 (highly suggestive of malignancy), or 3 (probably benign) with a recommendation for immediate evaluation. We defined a negative interpretation as BI-RADS of 1 (negative), 2 (benign finding), or 3 (probably benign) with no recommendation for immediate evaluation (19,20). We used data from the North Carolina Central Cancer Registry as well as pathology data from CMR participating mammography facilities and the University of North Carolina at Chapel Hill's Lineberger Comprehensive Cancer Center's Rapid Case Ascertainment program to identify breast cancer cases. Women were considered to have breast cancer if a diagnosis of invasive carcinoma or ductal carcinoma in situ occurred within 1 year of the screening mammogram (21). From the radiologists' BI-RADS interpretation and the cancer diagnosis, each mammogram was classified as true positive (positive mammogram with cancer diagnosed in the follow-up period), false positive (positive mammogram with no cancer diagnosed in the follow-up period), true negative (negative mammogram with no cancer diagnosed in the follow-up period), or false negative (negative mammogram with cancer diagnosed in the follow-up period.)

Information on the patient and image characteristics collected at the time of mammography included patient age, patient race, mammographic breast density, family history of breast cancer (defined as at least one first-degree relative with breast cancer), history of breast procedure, time since last mammographic examination, and year of examination. Breast density was categorized by the interpreting radiologist according to the BI-RADS assessments of almost entirely fat, scattered fibroglandular densities, heterogeneously dense, or extremely dense (20).

Performance measures included recall rate, sensitivity, specificity, PPV_1, and CDR of the screening mammogram. Recall rate was defined as the percentage of screening mammograms with findings interpreted as positive. Sensitivity was defined as the proportion of those with a positive screening mammogram interpretation among all those with a breast cancer diagnosis within the 1-year follow-up period. Specificity was defined as the percentage of screening mammograms with findings interpreted as negative among all patients who did not receive a breast cancer diagnosis in the follow-up period. PPV_1 was defined as the percentage of positive mammograms that resulted in a breast cancer diagnosis. CDR was defined as the number of true-positive mammograms for every 1000 screening mammograms.

Statistical Analysis

We describe the characteristics of the mammograms included in the study, separately for FFDM and SFM examinations. We also provide the average number of screening mammograms performed per technologist by modality. In addition, we computed the mean performance measure and 95% confidence intervals for recall rate, sensitivity, specificity, PPV_1, and CDR.

For each performance measure, we fit a mixed-effects logistic regression model to evaluate variability across technologists. The

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