Original Investigation

Technologists' Characteristics and Quality of Positioning in Daily Practice in a Canadian Breast Cancer Screening Program

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Rationale and Objectives: This study evaluates to what extent technologists' experience, training, or practice in mammography are associated with screening mammography positioning quality.

Materials and Methods: Positioning quality of a random sample of 1278 mammograms drawn from the 394,190 screening examinations performed in 2004–2005 in the Breast Cancer Screening Program of Quebec (Canada) was evaluated by an expert radiologist. Information on technologists' experience, training, and practice was obtained by mailed questionnaire. Multivariable Poisson regression models with robust estimation of variance were used to assess the association of technologists' characteristics with higher positioning quality.

Results: Of 254 randomly selected technologists, 220 (86.6%) completed the questionnaire. Participating technologists did 89.2% of available sampled mammograms (1088 of 1220), of which 45.9% were of higher positioning quality. Technologists who, in addition to mandatory training, followed at least 15 hours of hands-on training in positioning performed higher positioning quality (adjusted ratio = 1.3, 95%CI = 1.1–1.5) than technologists with no such additional training. Technologists providing at least 15 hours of continued medical education also performed higher positioning quality (adjusted ratio = 1.3, 95%CI = 1.1–1.5) than those who provided less than 15 hours of continued medical education. Being involved in film development and proportion of mammograms performed that are screening compared to diagnostic were also associated with positioning quality, although the latter association was less clear.

Conclusions: Extra hands-on training in positioning could further improve screening mammography positioning quality in the screening program because many technologists did not have such additional training.

Key Words: mammography; screening; quality; positioning; technologist.

INTRODUCTION

Mammography quality is believed to influence sensitivity and specificity of breast cancer screening. One study suggested that lower quality of positioning may reduce screening sensitivity (1). Other studies have suggested that poor mammography quality, including poor positioning, is associated with missed cancers (2) or later stage at diagnosis (3). Positioning is the aspect of mammography quality that is most frequently suboptimal (1,3–8). This finding was also observed in the Quebec Breast Cancer Screening Program (8).

Mammography technologists play a central role in the achievement of high-quality mammograms as they are responsible for positioning of the breasts. However, how technologists' characteristics influence mammography quality is understudied. Only two studies concerning the association between technologists' characteristics and mammography quality were identified. New technologists were found to perform better positioning quality than experienced technologists in one recent European study (9). In another study conducted in the Chicago area, facilities relying only on technologists dedicated to mammography were not found to perform higher quality mammograms than facilities relying on technologists with a mixed practice (3). These studies each analyzed only one technologists' characteristic. To our knowledge, no study has examined the association of a wide range of technologists' characteristics such as experience, training, and practice, with mammography quality.

In one study by Henderson et al. (10), technologists have also been studied in relation to radiologists' screening

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performance indicators such as the recall rate, specificity, sensitivity, and the cancer detection rate. The authors have demonstrated that these indicators varied significantly among technologists even when the variability related to radiologists was taken into account. Mammography quality, which includes positioning, could explain, at least in part, the observed variability in performance of screening. The same authors have also published a description of technologists' characteristics working in mammography in North Carolina (11). This study did not analyze the effect of technologists' characteristics on either mammography quality or screening performance.

Given the paucity of data on the relation of technologists' characteristics to mammography positioning quality, the objective of this study is to assess the relation of technologists' experience, training, and practice to screening mammography positioning quality.

MATERIALS AND METHODS

In the Quebec Breast Cancer Screening Program, women aged 50–69 years without a history of breast cancer are invited to mammography screening biennially. Women who participate in the screening program consent to the use of their data for program evaluation. The study was approved by the ethics committee of the (Centre hospitalier affilié universitaire de Québec).

Over the period from January 1 2004 to December 31 2005, there were 426,408 screening mammograms among asymptotic women without a history of breast cancer, breast implants, or mastectomies. The identification of the eligible population and sampling scheme have been described in detail elsewhere (8). The sampling scheme was planned to include all mammography facilities, as well as a large proportion of technologists and radiologists working in the program. Briefly, of the 394,190 eligible screening mammograms, a random sample of 1278 mammograms was drawn from a stratified two-stage cluster sampling scheme. The mammograms for 58 (4.5%) of these examinations could not be retrieved for various reasons (destroyed, damaged, lost, transferred to another facility, or retrieved by the patient).

The sample screening examinations were performed by 254 technologists, of whom 220 (86.6%) participated in the study. The 132 screening examinations performed by 34 technologists who did not participate were therefore excluded. Of the technologists who did not participate, 15 had changed jobs, 3 were on maternity or sick leave, 2 had retired, and 14 did not state a reason for nonparticipation. The sample available for analyses included 1088 (85.1%) screening examinations. The final sample did not include mammogram that was recalled because of technical or image quality problems.

Women Characteristics

At each screening examination, information on women, which includes but is not limited to age, body mass index, breast density (<25%, 25%–49%, 50%–75%, >75%), menopausal status, full-term pregnancies, screening history, indication of breast pain, and previous breast aspiration or biopsy, is collected and recorded in the screening program information system from which these data were retrieved.

Technologists' Characteristics

A questionnaire was sent by mail to all technologists who performed mammograms selected in the sample. This questionnaire enquired about three broad groups of factors: experience, training, and practice.

Experience includes years of experience in mammography, yearly mammography volume over the period 2004–2005, and proportion of total annual volume of mammograms that are screening mammograms (as opposed to diagnostic mammograms).

Training includes hours of continued medical education (CME) followed (<15, 15, 16–30, >30) and hours of CME given (<15, 15, 16–30, >30) in the three years before the study period. The questionnaire also enquired about whether the technologist has been responsible for training other technologists for positioning. Finally, the number of additional hours of hands-on training in positioning followed beyond the minimum required by the screening program was also collected.

Practice was measured for the period 2004–2005 and includes responsibility for film development, responsibility for deciding if film quality is adequate, supervision of other technologists, responsibility over quality control procedures, availability of feedback concerning repeated mammograms because of film quality, and average time allocated to the realization of a mammogram.

Technologists who performed mammograms in more than one facility in the sample were sent a separate questionnaire for each facility. This was done because the technologists' practice may vary from one facility to another. Only 12 technologists out of 254 in our sample did mammograms in two or more facilities over the study period. When one of these 12 technologists answered a question for one facility but not for the other(s), then the answer given for that one facility was imputed for the other(s). The questions concerned by this imputation pertained to technologists' characteristics that would not change from one facility to another, such as total mammography volume, experience, and training.

Mammography Positioning Quality

Screening examinations included four projections (one mediolateral oblique [MLO] and one craniocaudal [CC] mammogram for each breast). Evaluations are based on the Canadian Association of Radiologists' (CAR) criteria similar to those of the American College of Radiology (ACR) (5,8,12). Positioning quality was assessed by an experienced radiologist (M.-P.D.) who has evaluated the quality of mammograms for CAR accreditation. Positioning was given a score ranging from 1 (very poor quality) to 5 (very high quality). Possible positioning deficiencies contributing to the score included concave and/or thin pectoral muscle (MLO), pectoral muscle not within 1 cm of nipple line (MLO), poor visualization of posterior tissues (MLO or CC), sagging breast (MLO), portion of breast cutoff (MLO or CC), skin folds (MLO or CC), and excessive exaggeration (CC). There was also an "other category" in which other problems such as nipple(s) not in profile were mentioned. Quality evaluations were attributed to the whole screening examination and not to individual projections. All mammograms in the study were screen-film mammograms. In the rare instances that a screening examination had more than four views, the radiologist evaluating the mammograms had access to all the views made.

Positioning scores were dichotomized as lower quality (scores 1 and 2) and higher quality (scores 3, 4, and 5). Scores of 3 were considered adequate because, in our sample, this score never led to a failure of the overall evaluation of the mammogram.

STATISTICAL ANALYSES

To analyze technologists' characteristics in relation with the proportion of mammograms with higher positioning quality, Poisson regression models with robust estimation of variance were used to estimate adjusted proportion ratios (13–15).

As mentioned above, we collected information on 13 different technologists' characteristics pertaining to experience, training, and practice. This analysis was carried out in two steps. First, experience, training, and practice were analyzed in three separate models. The technologists' experience variables were analyzed together in a first model, training characteristics were analyzed in a second model, and practice characteristics were analyzed in a third model. Each of these models was adjusted for characteristics potentially associated with mammography quality: age (50–54, 55–59, 60–64, 65–69 years), breast density (<25%, 25%–49%, 50%–75%, >75%), body mass index (<25, 25–<30, ≥30 kg/m^2), menopausal (yes, no), previous full-term pregnancy (yes, no), screening history (initial mammogram in the program without previous screening mammogram, initial mammogram in the program with previous mammogram, and subsequent mammogram in the program), indication of breast pain (yes, no), and previous breast aspiration or biopsy (yes, no). The models were also adjusted for facility type (public/private) and facility volume of screening mammograms (<5,000, 5,000–<10,000, and ≥10,000). In a second step, technologists' characteristics associated to positioning quality with a P value <0.20 in each of the three models were selected and analyzed simultaneously in a final model, again adjusting for the same potential confounders. The P value for selection in the final model was chosen to make sure no important technologists' characteristics would be omitted.

For all models mentioned above, clustering of mammograms performed by the same technologist was taken into account with generalized estimating equations models with an independent working correlation matrix (16). All analyses were performed with SAS (Cary, NC, USA) and two-sided statistical tests.

RESULTS

In Table 1, the eligible mammograms, the complete sample, and the sample available for analyses are compared for important women characteristics, technologists' annual screening

TABLE 1. Characteristics of the Eligible Population, Sample, and Sample Available for Analyses†

	Population N = 394,190		Sample N = 1,278		Sample Available for Analyses N = 1,088	
	No.	(%)	No.	(%)	No.	(%)
Women characteristics						
Age, y, mean (SD)	58.5	(5.5)	58.5	(5.5)	58.6	(5.5)
Breast density ≥50%	136,017	(34.5)	430	(33.6)	367	(33.7)
Body mass index (kg/m^2),* mean (SD)	26.7	(5.2)	26.5	(5.2)	26.5	(5.1)
Parity (at least one child)	328,507	(83.3)	1,063	(83.2)	915	(84.1)
Menopausal	341,278	(86.6)	1,115	(87.2)	949	(87.2)
Indication of breast pain	27,868	(7.1)	82	(6.4)	67	(6.2)
Previous breast aspiration or biopsy	42,958	(10.9)	118	(9.2)	94	(8.6)
Screening history						
Initial mammogram in the program without prior mammograms	28,043	(7.1)	105	(8.2)	85	(7.8)
Initial mammogram in the program but at least one prior mammogram	76,973	(19.5)	246	(19.2)	202	(18.6)
Subsequent mammogram in the program	289,174	(73.4)	927	(72.5)	801	(73.6)
Technologists average yearly volume of screening mammograms (PQDCS), mean (SD)	898.1	(646.5)	747.0	(563.4)	769.3	(579.5)
Private facility	253,898	(64.4)	786	(61.5)	666	(61.2)

* Values are numbers (percentages), unless stated otherwise.

† 919 missing values in the population, one missing value in the sample, and one missing value in the sample available for analyses.

volume, and facility type. Distribution of women's characteristics is similar in all three groups. Technologists' annual volume was slightly lower in the sample because sampling method ensured inclusion of a minimum number of mammograms from all facilities even from those with lower volumes.

The three multivariable analyses pertaining to technologists' experience, training, and practice are presented in Table 2. Five technologists' characteristics had a P value of less than 0.20 and were therefore included in the final model: proportion of mammography practice focused on screening, hours of CME followed and hours of CME given, hours of hands-on positioning training, and whether the technologist is responsible for film development. Among the variables not associated with positioning quality were total mammography volume ($P = 0.38$), years of experience ($P = 0.96$), and being responsible for training others in positioning ($P = 0.86$).

The final analysis examining all variables identified in the previous step is presented in Table 3. Technologists who were involved in providing CME training (≥15 hours) were more likely to perform mammograms of higher positioning quality than those who had not provided training or had provided less than 15 hours of training (adjusted ratio = 1.3, 95%CI = 1.1–1.5, $P = 0.005$). Technologists who followed at least 15 additional hours of hands-on training in positioning had higher positioning quality (adjusted ratio = 1.3; 95%CI = 1.1–1.5, $P = 0.01$) than technologists who did not follow any additional hands-on training in positioning. Technologists for whom more than 25% and up to 75% of mammography practice is devoted to screening seemed to perform better positioning, although none of the categories excluded the null value. Finally, technologists who mentioned being responsible for film development also did mammograms of better positioning quality (adjusted ratio = 1.2, 95%CI = 1.0–1.4, $P = 0.03$) than technologists who were not responsible for film development. The majority of technologists (78%) were responsible for film development.

DISCUSSION

Technologists are recognized to play a central role in performing high-quality mammograms, that is, being responsible, among other things, for positioning. In our study, technologists who followed more than 15 hours of hands-on training in positioning, in addition to the 7 hours minimally required, performed mammograms with better positioning. Moreover, technologists who were involved in providing formal CME training or were responsible for film development also performed mammograms with higher positioning quality. Finally, the proportion of mammography practice allocated to screening was also associated with positioning quality. Our study is, to our knowledge, the first to analyze a broad range of technologists' characteristics in relation to positioning quality.

Based on our results, extra hands-on training in positioning seems to provide the best opportunity to improve screening mammography positioning quality. Technologists with this additional training had an increase of more than 20% in the proportion of mammograms with higher positioning quality. In our sample, 42.1% of technologists had followed no additional hands-on training in positioning and 31.8% had followed less than 15 hours of such training. An intervention to increase hands-on training has therefore the potential to benefit a large proportion of technologists and could have notable impacts on mammography quality in the program.

Initial education and hands-on training requirements for technologists performing screening mammograms vary throughout North America. In Quebec, technologists must complete a total of 50 hours of training in mammography, which includes 7 hours of formal hands-on training in positioning. No minimum amount of mammograms performed under supervision is established. In British Columbia, for instance, technologists must complete 40 hours of mammography training, which must include completion of a minimum of 50 mammograms supervised by an experienced technologist. In Ontario, training of new technologists for screening mammograms is managed site by site. In the United States and under the Food and Drug Administration regulations, technologists must perform 25 supervised examinations, which account for a maximum of 12.5 hours of the 40 contact hours of mandatory training in mammography (17). For British Columbia, Ontario, and the United States, it is difficult to know the level of emphasis given toward positioning. Also, the level of expertise of the instructor can vary. For example, having the requirements to perform screening mammograms is sufficient to be qualified as an instructor in the United States. In our study, 55 (23.6%) technologists mentioned having trained other technologists for positioning. This could include training of new technologists in a facility and need not to include formal training. These technologists did not perform better positioning than did the others.

Technologists providing formal CME hours (≥15 hours) performed better positioning than technologists who did not provide or provided less than 15 hours of CME training. Only 9.9% of technologists provided this amount of CME training.

The number of CME hours followed was not associated with higher positioning quality. To maintain their accreditation by the CAR, technologists must follow at least 15 hours of CME every 3 years. CME can take many forms such as conferences, seminars, lectures, and many others, including hands-on training. Some studies suggest that CME involving occasions for practicing skills or CME that are at least partially interactive are more likely to improve physician performance (18–20). This might apply to technologists as well and it should be taken into account if interventions to improve positioning are considered.

Technologists involved in film development performed better positioning than technologists not involved in film development. Most technologists in the sample were responsible for film development (78%). However, all other variables pertaining to practice, such as being responsible for quality control, were not associated with positioning quality.

Technologists who allocated more than 25% and up to 75% of their mammography practice to screening examinations

TABLE 2. Technologists' Experience, Training, and Practice Characteristics, and Positioning Quality

	Technologists*	Mammograms	Higher Positioning Quality		
	No.	No.	%	Adj. Ratio†	(95%CI)
Total	233	1088	45.9		
Model 1: experience‡					
Mammography experience (y)					
<5	22	98	45.9	1.0	
5–9	46	224	41.1	0.9	(0.7–1.2)
10–19	88	407	45.7	1.0	(0.8–1.2)
≥20	71	337	48.1	0.9	(0.7–1.2)
Missing	6	22	63.6		
P value				P = 0.96	
Average yearly TOTAL mammography volume (2004–2005)					
<1000	77	322	41.9	1.0	
1000–<2000	60	257	42.0	0.9	(0.8–1.1)
2000–<3000	50	247	48.6	1.0	(0.9–1.3)
≥3000	43	245	51.8	1.1	(0.9–1.3)
Missing	3	17	52.9		
P value				P = 0.38	
Proportion of mammograms that are screening (2004–2005), %					
>0–≤25	9	42	31.0	1.0	
>25–≤50	65	304	45.7	1.4	(0.8–2.4)
>50–≤75	99	452	49.1	1.6	(1.0–2.8)
>75–100	44	228	40.8	1.3	(0.7–2.2)
Missing	16	62	48.4		
P value				P = 0.03	
Model 2: training§					
Continued medical education followed (h)					
<15	10	41	43.9	1.0	
15	98	477	49.7	1.1	(0.8–1.5)
16–30	96	449	43.6	1.0	(0.7–1.4)
>30	27	116	39.7	0.9	(0.6–1.3)
Missing	2	5	40.0		
P value				P = 0.11	
Continued medical education given (h)					
<15	210	967	45.0	1.0	
≥15	23	121	52.9	1.2	(1.0–1.5)
P value				P = 0.04	
Trained others for positioning					
No	176	843	45.6	1.0	
Yes	55	240	47.1	1.0	(0.9–1.2)
Missing	2	5	40.0		
P value				P = 0.86	
Additional hands-on training (h) in positioning					
0	98	517	42.4	1.0	
<15	74	310	46.4	1.1	(0.9–1.3)
≥15	59	256	52.3	1.3	(1.1–1.4)
Missing	2	5	40.0		
P value				P = 0.006	
Model 3: practice¶					
Responsible for film development					
No	52	249	41.4	1.0	
Yes	181	839	47.2	1.2	(1.0–1.4)
P value				P = 0.04	
Responsible for film quality					
No	9	33	36.4	1.0	
Yes	224	1055	46.2	1.1	(0.7–1.7)
P value				P = 0.76	

continued on next page

TABLE 2. (*continued*).

	Technologists*	Mammograms	Higher Positioning Quality		
	No.	No.	%	Adj. Ratio†	(95%CI)
Supervision of technologists					
No	181	856	45.2	1.0	
Yes	49	224	48.7	1.1	(0.9–1.3)
Missing	3	8	37.5		
P value				P = 0.50	
Responsible for quality control at facility					
No	174	842	45.6	1.0	
Yes	59	246	46.7	1.0	(0.9–1.2)
P value				P = 0.73	
Receives feedback for rejected images for technical reasons					
No	90	456	46.7	1.0	
Yes	142	629	45.3	1.0	(0.8–1.1)
Missing	1	3	33.3		
P value				P = 0.74	
Average duration of a mammogram (min)					
≤5	21	118	44.9	1.0	
>5–10	161	749	47.0	1.0	(0.8–1.3)
>10	50	218	43.1	1.0	(0.7–1.3)
Missing	1	3	0.0		
P value				P = 0.82	

Adj, adjusted; CI, confidence interval.

* There are in fact 220 technologists. Technologists working in more than one facility were counted separately.

† All models are adjusted for women's age (50–54, 55–59, 60–64, 65–69), body mass index (<25, 25–<30, ≥30 kg/m^2), breast density (<25%, 25%–49%, 50%–75%, >75%), parity (at least one child), menopausal status (yes, no), previous breast aspiration or biopsy (yes, no), screening history (initial mammogram in the program without previous mammograms, initial mammogram in program with previous mammogram, subsequent in program), indication of breast pain (yes, no), facility type (public, private), and facility annual volume of screening mammograms (<5000, 5000–<10,000, and ≥10,000). Correlation among mammograms from the same technologist was taken into account in the model using the repeated option in GENMOD (SAS) by using an independent correlation structure.

‡ All experience characteristics are included in model 1. Because of missing values, the adjusted analyses included 999 women and 212 of 233 technologists.

§ All training characteristics are included in model 2. Because of missing values, the adjusted analyses included 1082 of 1088 women and 218 of 233 technologists.

¶ All practice characteristics are included in model 3. Because of missing values, the adjusted analyses included 1076 of 1088 women and 229 of 233 technologists.

seemed to perform higher positioning quality. These technologists have a more balanced practice between screening and diagnostic mammograms, which may enhance their skills for a diversity of projections. However, only nine (3.9%) technologists in our sample mentioned allocating 25% or less of mammography practice to screening, and no category excluded the null value.

Our study, unlike a prior European study, did not find that years of experience were associated with mammography quality (9). van Landsveld-Verhoeven et al. observed that experienced mammographers performed lower positioning quality than did "new mammographers" who were defined as mammographers completing their hands-on training. The examination allowing them to perform screening mammograms consists in part of the evaluation of a random sample of 50 mammograms performed during their training. The new technologists were therefore aware that they were performing mammograms that could be evaluated. Moreover, their mammograms were performed under supervision. In our study, only technologists who had completed their qualifications were included.

Technologists cannot be expected to perform screening examinations that always satisfy the ACR/CAR positioning quality criteria (5). This is due in part to characteristics of women, which can sometimes prevent some criteria, such as adequate presentation of the pectoral muscle, to be fulfilled (5,21–23). Technologists with excellent positioning skills might, however, better adapt their technique in challenging situations such as when the woman is obese, is stressed, has a prominent sternum, or is in a wheelchair (23–25). In these situations, a screening examination, although not satisfying all positioning requirements according to the ACR/CAR criteria, could still allow a clear visualization of most breast tissue. Our study could not evaluate the impact of technologists' abilities in these situations. Thus, interventions aimed at increasing technologists positioning skills, such as extra hands-on training, could have a broader positive impact than simply an increase in the proportion of mammograms fulfilling the ACR/CAR criteria.

TABLE 3. Selected Technologists' Characteristics and Positioning Quality

	Technologists*	Mammograms*	Higher Positioning Quality		
	No.	No.	%	Adj. Ratio†,‡	(95%CI)
Proportion of mammograms that are screening (2004–2005), %					
>0–≤25	9	42	31.0	1.0	
>25–≤50	65	304	45.7	1.4	(0.8–2.4)
>50–≤75	99	452	49.1	1.5	(0.9–2.6)
>75–100	44	228	40.8	1.2	(0.7–2.1)
P value				0.03	
Continued medical education followed (h)					
<15	10	41	43.9	1.0	
15	98	477	49.7	1.0	(0.7–1.5)
16–30	96	449	43.6	0.9	(0.6–1.3)
>30	27	116	39.7	0.8	(0.5–1.3)
P value				0.13	
Continued medical education given (h)					
<15	210	967	45.0	1.0	
≥15	23	121	52.9	1.3	(1.1–1.5)
P value				0.005	
Additional hands-on training (h) in positioning					
0	98	517	42.4	1.0	
<15	74	310	46.4	1.1	(1.0–1.3)
≥15	59	256	52.3	1.3	(1.1–1.5)
P value				0.01	
Responsible for film development					
No	52	249	41.4	1.0	
Yes	181	839	47.2	1.2	(1.0–1.4)
P value				0.03	

Adj, Adjusted; CI, confidence interval.

* Totals may vary because missing information is not presented in this table.

† Adjusted for women's age (50–54, 55–59, 60–64, 65–69), body mass index (<25, 25–<30, ≥30 kg/m^2), breast density (<25%, 25%–49%, 50%–75%, >75%), parity (at least one child), menopausal status (yes, no), previous breast aspiration or biopsy (yes, no), screening history (initial mammogram in the program without previous mammograms, initial mammogram in program with previous mammogram, subsequent in program), indication of breast pain (yes, no), facility type (public, private), and facility annual volume of screening mammograms (<5000, 5000–<10,000, and ≥10,000). Correlation among mammograms from the same technologist was taken into account in the model using the repeated option in GENMOD (SAS) by using an independent correlation structure.

‡ Because of missing values, the adjusted analyses included 1025 of 1088 women and 217 of 233 technologists.

Our study has some limitations. Mammograms were done with the film-screen technology now widely replaced by digital technology. However, criteria associated with good positioning have remained essentially the same with digital technology (26). Technologists' role in correctly positioning the breast remains essential today (24). Another limitation is the intrinsic subjectivity of positioning quality evaluations (4,23,27). Mammography quality and positioning evaluations were shown to exhibit low inter-rater agreement in a subsample of our study (8) as in other studies (4,27). The radiologist in our study was demanding, and the inclusion of other radiologists in the evaluation process could have changed the overall proportion of mammograms with high positioning quality (8). However, this type of misclassification should be nondifferential as positioning evaluation was done without knowledge of data on technologists' characteristics, and such nondifferential misclassification is unlikely to explain observed associations (28). Finally, no information pertaining to body habitus (such as prominent sternum) was available in the information system.

Our study also has several strengths. The participation rate in our study was high (86%), and very few mammograms of the sample could not be retrieved (<5%). Almost all eligible facilities participated (80 of 83), and the technologists were randomly selected in each facility. The results should therefore be representative of all the technologists performing screening mammograms in our program. Also, the radiologist who assessed mammography quality had experience evaluating mammograms in the context of CAR accreditation. Information pertaining to the facility or the technologists was masked on the mammograms, thus reducing the risk of observer bias. Finally, we were able to adjust for important potential confounders such as case mix and characteristics of facilities.

In conclusion, our study shows that technologists involved in providing formal training, those involved in film development, and those who have followed extra hands-on training in positioning perform mammograms of higher positioning quality. Extra hands-on training in positioning appears to offer one of the best approaches to improve mammography positioning quality in the program, as many technologists have not had such additional training.

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