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A review of mammographic image quality in Papua New Guinea

Ruth Pape, BMIS, MHSci, GCertEd,[1] Kelly Maree Spuur, BApSc(MedImag), PhD, GradCertLearn&TeachHigherEd,[2] Jenny Maree Wilkinson, BSc(Hons), PhD, GradDipFET, MHEd, GCBiostatistics,[3] & Aileen Zuhukepe, BMIS[4]

[1]School of Medicine and Health Sciences, University of Papua New Guinea, Port Moresby, Papua New Guinea
[2]School of Dentistry and Medical Sciences, Charles Sturt University, Wagga Wagga, New South Wales, Australia
[3]Endeavour College of Natural Health, Melbourne, Victoria, Australia
[4]Radiology Department, Port Moresby General Hospital, Port Moresby, Papua New Guinea

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Correspondence
Kelly Maree Spuur, School of Dentistry and Medical Sciences, Charles Sturt University, Wagga Wagga, NSW 2678, Australia.
Tel.: +61 2 69 33 4550;
E-mail: kspuur@csu.edu.au

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Abstract

Introduction: To report for the first time the image quality of mammograms performed in Papua New Guinea (PNG) using the Perfect, Good, Moderate, Inadequate (PGMI) image evaluation system (IES); and to benchmark the image quality against BreastScreen Australia (BSA) National Accreditation Standards (NAS). **Methods:** A retrospective image quality analysis of the de-identified mammograms of 102 women imaged at the Port Moresby General Hospital (PMGH) was undertaken using the PGMI IES. Each craniocaudal (CC) and mediolateral oblique (MLO) image was assigned a grade and the reasons for the grade recorded. Age was recorded in years. Simple frequency analysis was undertaken and comparison with BSA NAS 2.4 was made. **Results:** Women were aged between 25 and 74 years. There were 111 CC views and 109 MLO views. The most frequent individual grade for the CC view was G (83.8%) and for the MLO view M (72.48%); and for a routine series (four images), P and G combined (14.8%). Non-visualisation of the IMA (28%), nipple not in profile (26%) and short length of pectoral muscle (12%) were the most cited reasons for assigning an M grade. **Conclusion:** The reported image quality is not commensurate with that required by BSA (P and G > 50%) and while common positioning errors can be rectified through education and training, it is also important to recognise the complex challenges faced by PNG radiographers in obtaining mammographic images that extend beyond education and training and reflect the emerging nature of the modality as well as wider health, economic and other issues. This work raises the need for national standards, dedicated equipment, and radiographer education to best serve the women of PNG.

Introduction

Globally, breast cancer represents 1 in 4 cancers diagnosed in females and is the most common cancer diagnosed worldwide.[1,2] Breast cancer is the most frequently diagnosed cancer in Papua New Guinean (PNG) women, with 1570 cases being diagnosed in 2020. However, these data should be prefaced with the knowledge that both the true number of women in PNG and the absolute burden of disease remain unknown.[3,4] There are limited options for any type of breast imaging in PNG and women typically only present to health practitioners when the disease is advanced.[5] The age-standardised rate (ASR)(World) for breast cancer incidence and mortality in PNG is 46.6 per 100,000 and 27.2 per 100,000 respectively; rates for individual countries vary and may be influenced by a range of factors including healthcare access and infrastructure, including screening programs, as well as cultural and other influences.[6,7]

Where screening programs for the early detection of breast cancer are in place, such as in the United Kingdom ((National Health Breast Screening Program (NHBSP))[8] or Australia (BreastScreen Australia (BSA)),[9] and are supported by access to treatment, mortality from breast cancer is low despite increased incidence: UK 87.7 per 100,000/14.0 per 100,000 (incidence/mortality)[10] and Australia 96.0 per 100 000/11.7 per 100,000 (incidence/mortality).[11] High mortality rates from breast cancer in PNG (27.2 per 100,000) reflect the lack of early detection services. The main reason for undertaking mammography at Port Moresby General Hospital (PMGH) is for advanced breast cancer, which represents 9% of hospital admissions.[12]

Whilst the PNG government acknowledges the impact of breast cancer and the need for improved imaging in their National Cancer Policy 2015,[12] there is no government-funded breast screening program currently available. Rather Government and non-government efforts focus on harm minimisation and early diagnosis based on awareness of early clinical signs and symptoms. This differs from dedicated population-based screening services whose aim is to identify preclinical lesions.[13] Although the PNG Government has acknowledged the need for a national screening program in its Cancer Action Priorities for 2017–2021, it is simply not feasible to progress this aim with the current available resources.[4]

The lack of a dedicated screening program in PNG means that there is also a lack of formal oversight and governance, quality control and quality assurance of the images produced. In most Western countries, mammographic imaging undertaken outside of screening programs (private diagnostic imaging) is overseen and accredited by the professional bodies of radiologists, such as the Royal Australian and New Zealand College of Radiologists (RANZCR) in Australia.[2] This is not the case in PNG, although there is an effort to align practice to the standards of the RANZCR[2] and the International Atomic Energy Agency (IAEA)[14] as well as BSA.

The PGMI (perfect, good, moderate and inadequate) image evaluation system (IES) is used in the screening programs of Australia,[15] the United Kingdom,[16] New Zealand[17] and in many European countries.[18] In these programs, the PGMI IES is used to monitor the image quality produced by individual radiographers and the Service as well as being used as a tool to facilitate external audit.[15] The National Accreditation Standards (NAS) of BSA require the overall repeat rate for a Service to be ≤2% of all screening images taken (NAS 2.5.2) and that each radiographer achieves 50% or greater P or G grades annually from a random selection of 50 paired mammograms (NAS 2.4).[15]

Radiographers at the PMGH have been using the PGMI IES for almost 5 years after some radiographers undertook clinical training in Australia; however, anecdotally its application has a shallow foundation, meaning its use has not been strongly emphasised and there is no policy or requirement for any grade to be formally recorded. Instead, its use is limited and informal, being applied prospectively in the clinical setting to aid decision-making around repeat imaging.

Reduction in mortality from breast cancer relies on the consistent production of high-quality mammographic images.[19] It is well evidenced that optimal image quality leads to earlier detection, higher detection rates, fewer interval cancers, and reduced dose from the minimisation of repeat imaging.[20,21] Quality improvement is only possible with an understanding of current issues. It is therefore important to benchmark current standards of imaging to provide insight for the development of any future population-based screening program in PNG, as well as to support continuing professional development and training for staff and feedback on equipment. This study, documents for the first time, the image quality of mammograms produced at the PMGH Radiology Department using the PGMI IES.

Methodology

A retrospective analysis was undertaken of the de-identified, paired craniocaudal (CC) and mediolateral oblique (MLO) mammograms of 102 women performed using an Alpha RT computed radiography (CR) unit at the PMGH, imaged between 2015 and 2017. Due to long-standing faults with the automatic exposure control (AEC), all images were performed using manual exposure techniques. Images were retrieved from the picture archiving and communication system (PACS) and reviewed in the clinical setting by one of the authors (RP), a qualified Radiographer with 16 years of mammographic experience and who has undergone specific training in using the PGMI IES in Australia. Images were evaluated and categorised as either P, G, M or I as described by the BSA NAS.[15] Each paired set of images was independently and blindly reviewed three times, with discrepancy addressed by consensus. The rationale for each grade was noted. Secondary analysis was undertaken by the author (KS), who has 30 years of clinical experience in mammography and involved a review of the recorded rationale and the corresponding grade. This secondary review confirmed the appropriateness of each individual grade. Age was recorded in years. Analysis was by simple frequency analysis. Results for image quality performance were

compared with BSA NAS 2.4 only, as there were no available records for repeat imaging analysis for NAS 2.5.2.

Ethics was approved by the School of Medicine and Health Science Research and Ethics Committee (SMHS REC) Project Approval Number: 0119. Permission for collecting data was granted from the PMGH Director of Medical Services and the Officer in Charge of Residential Medical Imaging Technologists and Medical Imaging Students, and the Head of the PMGH Mammography Unit.

Results

There were 102 women imaged aged with a mean of 49.1 years (SD 9.1 y) (Fig. 1). Although the age range was from 25 to 74 years, 90% of the women were aged 37–60 years. There were 111 CC views and 109 MLO views available for review. Many images were unable to be opened in PACS due to a technical error in the system. Some patients had only one unaffected breast examined or imaging was noted not to have progressed due to presentations, such as mastectomy, mastalgia or surgery. Eighty-eight women had full routine (4 view) imaging retrieved.

Overall, the majority of CC and MLO view images were rated as either G or M, with very few images rated as P or I. There were 81 women with bilateral CC views, 30 with one side only (left or right) and 2 with no CC views available for review. The most frequent individual grade for the CC view was G (83.78%); with only one image rated as P (0.01%), the P and G grades combined totalled 93 (83.79%) (Table 1). There were 98 women with bilateral MLO views, 20 with one side only (left or right) and two with no MLO images available for review. The most frequent grade for the MLO view was M (72.48%); similar to the CC view, there was only a single image rated as P (0.01%), the P and G individual grades combined totalled 28 (25.69%) (Table 2). Of the 88 women who had full routine (4 view) imaging retrieved for review, M (84.09%) was the most frequent grade awarded followed by combined P and G (14.77%) (Table 3). Non-visualisation of the IMA (28.04%), nipple not in profile (25.70%), and short length of pectoral muscle (12.15%) were the most cited reason for downgrading images (Table 4).

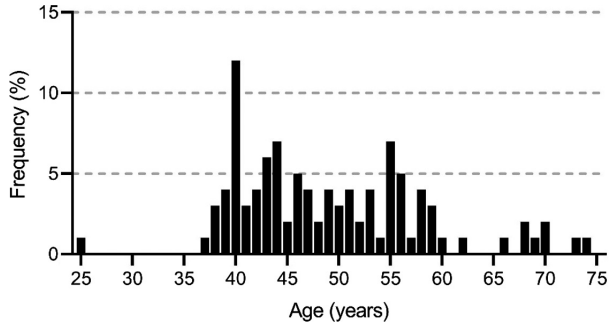

Figure 1. Age distribution of women undergoing mammographic imaging.

Discussion

The age profile of the women undergoing imaging at PMGH is younger than those of Western screening programs and is consistent with the population demographics for PNG where the median age is 22 years and the average life expectancy for females is 65.8 years. In addition, the PMGH mammography services more closely resemble Western diagnostic services in that age is not targeted, and that the burden of breast cancer in PNG affects younger women compared with most Western countries, including Australia.[22] The mean age of women in the study was 49.51 years, which is just younger than the BSA target age group which is 50–74 years.[9]

The study has been impacted by difficulties retrieving images from the PACS, however, there were 88 paired mammograms available for analysis. As screening services record grades for paired series only, this is important for direct comparison. As expected, the CC view had more G (83.78%) than M (13.51%) grades and this trend was reversed for the more complex MLO view G (25.69%) and M (72.48%). The image quality of the data set was found not to be commensurate with that required by BSA in that the sample reviewed failed to meet the requirement that 50% or more of a selection of paired images, be graded P and G > 50%, noting that the lowest grade in the series is the one recorded.[15] This is a very high level of compliance, that other programs such as the Quebec Breast Cancer Screening Program (49.7% non-compliance) have also previously failed to meet, despite having dedicated screening programs and fully accredited centres.[23] It should also be acknowledged that the PGMI

Table 1. Grade frequency for each craniocaudal (CC) view (N = 111)

	Perfect (P)	Good (G)	Moderate (M)	Inadequate (I)
Left (L)	1 (0.01%)	8 (7.21%)	4 (36.04%)	0 (0.00%)
Right (R)	0 (0.00%)	9 (8.11%)	6 (5.41%)	2 (1.80%)
Both (L and R)	0 (0.00%)	76 (68.47%)	5 (4.50%)	0 (0.00%)
Total	1 (0.01%)	93 (83.78%)	15 (13.51%)	2 (1.80%)

Table 2. Grade frequency for each mediolateral oblique (MLO) view ($N = 109$)

	Perfect (P)	Good (G)	Moderate (M)	Inadequate (I)
Left (L)	1 (0.01%)	2 (1.83%)	6 (5.50%)	1 (0.01%)
Right (R)	0 (0.00%)	7 (6.42%)	4 (3.67%)	0 (0.00%)
Both (L and R)	0 (0.00%)	19 (17.43%)	69 (63.30%)	0 (0.00%)
Total	1 (0.01%)	28 (25.69%)	79 (72.48%)	1 (0.01%)

Table 3. Grade frequency for each full routine (4 view) imaging series ($N = 88$)

	Perfect (P)	Good (G)	Moderate (M)	Inadequate (I)
Total (N = 88)	0 (0.0%)	13 (14.77%)	74 (84.09%)	1 (1.14%)

Table 4. Imaging deficiencies

Deficiency*	Number (N)	Percentage of total deficiencies reported* (%)
Infra mammary angel (IMA) not visualised or cut off	60	28.04%
Nipple not in profile	55	25.70%
Length of pectoral muscle not to the nipple line (NL)	26	12.15%
Skin folds	20	9.34%
Tissue cut off	15	7.01%
Under exposed	9	4.20%
Pectoralis major muscle cut off	9	4.20%
Positioning error not specified	6	2.80%
Under compression	4	1.87%
Over exposed	3	1.40%
Artefact (not software)	3	1.40%
Pectoralis major muscle not visualised	2	0.93%
Asymmetry	1	0.47%
Software artefact (equipment calibration)**	1	0.47%
Total	214	100%

*An image may present with more than one deficiency.
**This is in addition to a known software artefact affecting almost all images which is not reported here.

IES is known to be inherently subjective, lacking reliability and validity, and used variably between and within groups of radiographers and across sites.[24] There is however no alternate system in place and the assigning of M grades in this study is evidenced to be a result of obvious imaging deficits and therefore unlikely to be the result of subjective appraisal alone.

Mammography training in PNG is undertaken in the clinical setting postgraduation without a requirement for specialised postgraduate education. This, combined with a small volume of cases currently shared between two radiographers, means that opportunity to consolidate skills is extremely limited. The PMGH has imaged women for over 10 years, completing approximately 30 patients per month with an estimated annual throughput of 360 patients.[25] In comparison, a typical BSA radiographer has been reported to screen 93 women per week or approximately 5000 women per year[26] with anecdotal numbers for some Services standing at 140 per week or 6 720 per year.

This lack of exposure to high volume mammography may impact radiographer competence. In this study, non-visualisation of the IMA (28.04%), the nipple not being in profile (25.7%) and short length of pectoral muscle on the MLO view (12.15%) were the most cited reason for downgrading images. These errors are not unique to PNG radiographers, with some having been identified among the top five positioning challenges in mammography.[27] Not locating the woman anterior to the receptor, incorrect receptor height, anatomical presentation and not having the breast aligned parallel to the receptor are all common causes of these errors.[2,19] Education and additional training can easily overcome most of these issues. Implementation of a dedicated population-based screening program with accreditable operating standards would support and monitor such training and provide a framework for ongoing quality assurance.

Breast size directly impacts both the radiographer's ability to image the breast in one exposure and to manipulate the breast correctly onto the receptor. The tissue cut off (7.01%), evidenced in this study, may be an outcome of a small receptor size and poor positioning technique. It is noted that the 'jigsaw', 'mosaic' or 'tile' technique[28,29] is utilised at PMGH for larger breasts as is best practice, however, cut off was still evident.

Image artefacts can be caused by issues external to the imaging chain or within it. Skin folds (external) are a significant challenge to prevent in countries with high humidity such as PNG. Anecdotally, skin folds can also be more prevalent when imaging the larger breast. Whilst the screening programs of most Western countries utilise the most up to date full field digital mammography (FFDM) equipment and training, the CR mammography unit at PMGH is technologically a generation behind. Known technical issues including a faulty AEC have impacted images since around 2017 causing exposure and software artefacts, most of which are not captured here, and have resulted in the need for the routine use of

manual exposures. Issues with exposure accounted for 5.60% (n = 12) of images either being over (1.40%) or underexposed (4.20%) due to poor equipment calibration, exposure parameter selection related to the technical knowledge of the operator or inadequate compression. Increased education and dedicated use of the automatic exposure control (AEC) feature of the unit, as is best practice, would decrease the rate of this issue.

Radiographer and patient interactions are fundamental to the success of any breast imaging. The ability of the patient to comply with the requirements of imaging was outside the scope of this study. It is known however that some of these women were in great pain with advanced presentations and could not cooperate well. On occasion in any screening setting, there will be images that are graded I but submitted for reporting. This may be evidence of a difficult presentation or the refusal of a woman to consent to additional imaging. The reason the two I graded images in this study were not repeated is unknown.

Study limitations include that the sample size is small and opportunistic and that the study was significantly impacted by issues with accessing images from PACS, meaning that some image series could not be fully assessed and not all women imaged during the study period could be included.

Conclusion

The image quality examined in this study reflects a standard of imaging below that expected by the well-funded Western screening program BSA. Common positioning errors however may be able to be rectified through further education and training. The authors fully acknowledge the complex challenges faced by PNG radiographers in obtaining mammographic images and do not wish to detract from their efforts. Rather it is the wish of the authors to bring to attention the need for the ongoing monitoring of facilities through an accreditation program, dedicated equipment and improved radiographer education to best serve the women of PNG. Proper image quality cannot be assured without addressing each of these issues.

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Conflict of Interest

The authors declare no conflict of interest.

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