RESEARCH ARTICLE

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Outcomes of an Opportunistic Screening Mammography Program Using the Mobile Mammography Unit in Sindh, Pakistan

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Abstract

Background: This study evaluated opportunistic screening mammography outcomes in a mobile mammography unit (MMU), performed for breast cancer detection among populations with limited access to breast imaging in Pakistan. **Methods:** This cross-sectional study was conducted among women undergoing screening at the MMU stationed at two secondary hospitals of Aga Khan University Hospital from March 2019 to March 2021. Women aged ≥40 years and those <40 years at high risk for breast cancer were screened. Performance indicators included the cancer detection rate (CDR), BI-RADS assessment, and recall rate. **Results:** 1042 women were screened at the MMU. The median age was 49 years. 76.6% of women underwent screening for the first time. 64.7% of women had dense or heterogeneously dense breasts; however, heterogeneously dense breasts constituted the largest proportion (57.1%). The overall recall rate was 65.5%, out of which breast ultrasound was advised in 59.8% for dense breasts and additional mammographic views in 10.3% because of suspicious findings. Biopsy was advised for 20 women, of whom 13 (65%) completed the biopsy, yielding 11 cancers (CDR 10.6 per 1,000), Of all the diagnosed malignancies, 8 were invasive, 2 were ductal carcinoma in situ and histology of one cancer was unknown, with 72.7% of invasive cancers being node negative. **Conclusion:** This cohort of a largely first-time screened population with dense breasts yielded a high CDR and predominantly early-stage, node-negative cancers. The elevated CDR highlights a substantial reservoir of undiagnosed disease in underserved populations. MMU-based screening is known to be effective at identifying early breast cancers; however, its deficiency in a low-middle-income country (LMIC), such as Pakistan, calls for the immediate establishment of screening programs, preferably in mobile units across the country. Integrating MMUs with targeted outreach, on-site diagnostic tools, and patient navigation may improve follow-up adherence and further enhance early detection efforts.

Keywords: Breast Cancer- Mobile Mammography Unit- Screening- Cancer Detection Rate- Recall Rate

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Introduction

Breast cancer (BC) cases are accelerating at an alarming rate in women around the world [1]. According to the GLOBOCAN Report 2022, BC has the highest incidence and mortality rate of all oncological diseases diagnosed in Pakistan. Despite advances in medicine, the mortality rate is 2.8 times higher than in neighboring countries [2]. Multiple studies suggest that late presentation and diagnosis, delayed referral to appropriate services, lack of BC screening facilities and BC awareness, low educational level, financial constraints, or precancerous risk factors are all contributing to the high mortality rate [3, 4]. 89.8% of Pakistani patients with symptomatic BC have a delayed (>3 months) presentation to the specialist, with 97.9% of these women initially having painless lumps or no symptoms, highlighting the critical importance of screening and early detection for improving BC prognosis [2]. Early diagnosis and treatment can reduce the mortality rate by 20% and improve the 5-year survival from 12% (diagnosed at later stages) to 88% (diagnosed early at a less advanced stage) [5].

Routine mammographic screening is considered the most effective method to detect BC at an early stage, ultimately leading to better treatment options and improved survival rates [6]. BC screening programs are broadly categorized as organized population-based screening and opportunistic screening [7]. Organized

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screening involves systematic invitations to eligible individuals within a defined population, centralized registries, quality assurance systems, and standardized follow-up mechanisms. In contrast, opportunistic screening occurs when individuals undergo screening during routine healthcare encounters or through targeted outreach initiatives without a formal population registry or invitation system [7]. In many low- and middle-income countries (LMICs), including Pakistan, the infrastructure required for organized population-based screening programs, such as national registries, systematic recall systems, and large-scale public funding, is often limited. Consequently, opportunistic screening delivered through hospital-based services or outreach initiatives such as Mobile Mammography Unit (MMUs) represents a practical strategy to expand access to early BC detection while health systems progressively develop organized screening frameworks.

In Pakistan, screening mammography utilization is significantly low, around 3.5% reported in Karachi, verifying the underutilization of screening in Pakistan [8]. MMU has been known to improve BC screening by eliminating access and financial barriers to underserved women and incorporating greater patient diversity in terms of socioeconomic status, race, and ethnicity [9]. MMUs have been proposed as a pragmatic strategy to improve access to screening by bringing imaging services closer to communities with limited healthcare infrastructure. However, evidence regarding the effectiveness and performance of MMU-based screening programs in Pakistan remains scarce. Therefore, to overcome the main obstacles to early BC detection, an MMU was set up at two secondary hospitals of the Aga Khan University Hospital (AKUH) in two different cities of the province, i.e., Karachi and Hyderabad. The MMU provided easy-to-access screening for patients at a reduced price.

Therefore, the objective of this study was to evaluate the outcomes of an opportunistic mammography screening program conducted through an MMU in Sindh, Pakistan, by measuring key screening performance indicators, including cancer detection rate (CDR), recall rate (abnormal interpretation rate - AIR), Breast Imaging-Reporting and Data System (BI-RADS) distribution, and biopsy outcomes, among women screened between March 2019 and March 2021.

Materials and Methods

This is a cross-sectional study conducted using data of screening mammograms performed in the MMU stationed at the two secondary hospitals of AKUH, i.e., The Aga Khan Hospital for Women Karimabad (AKHWK) in Karachi, and The Aga Khan Maternal and Child Care Center (AKMCCC) in Hyderabad from 2019 to 2021. Screening mammography at the MMU were performed using the computed radiography (CR) system which used cassette-based phosphor storage plates, which were then scanned by the computerized system into a digital format for image processing, archiving, and presentation. The images were transferred via picture archiving and communication system (PACS) to the main tertiary care hospital (AKUH) in Karachi where expert radiologists specializing in breast imaging reported the mammograms within 24 hours using the BI-RADS scoring system. Screening at the MMU halted due to covid pandemic and could not be resumed due to the older version of the mammogram system installed within it.

Following the American College of Radiology (ACR) guidelines, female patients aged ≥40 years, and those <40 years with a valid prescription for being high risk for BC, such as strong family history of breast/ovarian/prostate/pancreatic cancer, BRCA/other germline mutations, prior chest radiation, history of atypical breast lesions, or reproductive/hormonal factors, were screened at the MMU. Patients with symptoms of BC (e.g. lump, skin changes, nipple retraction, etc.), prior history of BC, those who had breast implants, pregnant females, and those who were breastfeeding were excluded.

Patient data, including the patient's age, marital status, family history, mammographic breast density, findings of imaging undertaken, additional tests, and biopsy results were collected. Screening mammograms were assessed according to BI-RADS classification. Participants with extremely dense and heterogeneously dense breasts were advised to receive an additional ultrasound for better visualization of the breast tissue. Participants with suspicious mammographic findings on screening were recalled for additional diagnostic views. The additional views, such as cone compression, magnification, true lateral views, etc., were performed at AKUH main campus in Karachi on the Siemens Mammomat and GE Pristina digital systems along with digital breast tomosynthesis. Patients with a final BI-RADS assessment of 4 and 5 (after additional diagnostic views and/or ultrasound) were actively followed up to ensure the biopsy was performed. Follow-up calls were made to these patients till March 2023 in case the biopsy was not pursued.

Measures and Definitions

At both the centres where MMU was stationed, sociodemographic and breast related information were collected from women at the time of their screening using a comprehensive questionnaire. Mammographic breast density was classified by radiologists based on mammographic assessment using the BI-RADS density categories as fatty, scattered fibroglandular density, heterogeneously dense, and extremely dense. Screening assessments were categorized into six groups according to BI-RADS assessment levels: 0 (incomplete, needs additional imaging evaluation), 1 (negative), 2 (benign), 3 (probably benign), 4 (probably suspicious for malignancy), and 5 (highly suspicious for malignancy). The Abnormal Interpretation Rate (AIR)/recall rate was defined as the percentage of women who were called back for additional tests after their initial screening mammogram, such as BI-RADS category 0, 3, 4 or 5. Cancer Detection Rate (CDR) was calculated per 1000 screening examinations.

Data analysis

Continuous variables were reported as median (interquartile range - IQR), and all categorical variables were reported as frequency (percentage). Patient adherence to follow-up testing was calculated using the ratio of the total number of biopsies performed and the total number of biopsies advised. The CDR was calculated by finding the proportion of women in whom cancer was diagnosed. Data was collected and analyzed using the Statistical Package for Social Sciences (SPSS) Version 21.

Ethical approval was obtained from the AKUH ethical review committee (ERC 3350), and the manuscript was drafted following the STROBE checklist.

Results

Data for patient demographics and radiological characteristics along with additional imaging are stated in Table 1. A total of 1042 females underwent screening at the MMU. The median age (IQR) was 49 (12) years. The sample constituted 56.8% of women from Hyderabad and 43.2% from Karachi. 55% (573) of the females were postmenopausal. Most patients had heterogeneously dense breasts (57.1%), followed by fibroglandular breast parenchyma (31.7%) and extremely dense breasts (7.6%). A total of 107 (10.3%) participants with suspicious findings on screening mammogram were recalled for additional mammographic imaging. Ultrasound breast was advised in 623 (59.8%) females owing to either suspicious findings on mammogram or dense and heterogeneously dense breasts (Table 2). Thus, a total of 65.5% of women were recommended additional imaging, ultrasound or both, out of which 47 (4.5%) patients had both additional mammographic views and ultrasound.

Screening mammography examination outcomes are mentioned in Table 3. Altogether, 20 patients with BI-RADS 4 and 5 lesions were identified after completing their additional imaging and were thus advised biopsy.

Table 1. Sociodemographic, Reproductive & Clinical Characteristics of Women in Screening Mammography at MMU 2019-2021 (n=1042)

Characteristics		n %
Age in years median (IQR)	49 (12)	
Menarche (years)		13.4 (1.4)
Marital status	Married/Divorced/Widow	1010 (96.9)
	Single	32 (3.1)
Parity	0	104 (10)
	1-3	605 (58.1)
	> 3	333 (32)
Age of mother at first born in years median (IQR)		23 (6)
Breastfeeding	Yes	908 (87.1)
	No *	134 (12.9)
Family history of breast cancer	Yes	176 (16.9)
	First Degree Relatives	106 (10.2)
	Second Degree Relatives	70 (6.7)
	No	866 (83.1)
Menopausal status	Premenopausal	469 (45)
	Postmenopausal	573 (55)
OCP use	Yes	99 (9.5)
	No	943 (90.5)
HRT use	Yes	30 (2.9)
	No	1012 (97.1)
Prior Screening Mammogram performed	Yes	244 (23.4)
	No	798 (76.6)
Breast density	Extremely dense	79 (7.6)
	Heterogeneously dense	595 (57.1)
	Fibroglandular	330 (31.7)
	Fatty	38 (3.6)
City	Karachi	450 (43.2)
	Hyderabad	592 (56.8)
Recall for Additional Views on Screening Mammogram	Yes	107 (10.3)
	No	935 (89.7)
Ultrasound Breast Advised	Yes **	623 (59.8)
	No	419 (40.2)

IQR, Interquartile Range; OCP, Oral Contraceptive Pills; HRT hormonal replacement therapy; * Includes both single and nulliparous women; ** Includes all dense, heterogeneously dense and suspicious mammograms

Table 2. Distribution of BI-RADS Classification and Recommendation for Additional Imaging and/or Ultrasound

BI-RADS assessment	Screening Mammogram		Additional Imaging		Ultrasound Advised	
	n	%	n	%	n	%
0	672	64.5	107	10.3	612	58.7
1	130	12.5	-	-	-	-
2	229	22	-	-	-	-
3	-	-	-	-	-	-
4	10	1	-	-	10	1
5	1	0.1	-	-	1	0.1
Total	1042	100	107	10.3	623	59.8

BI-RADS, Breast Imaging-Reporting and Data System

Table 3. Screening Mammographic Examination Outcomes at the MMU (2019-2021)

Measurement and Data	Value, n (%)
Total no. of examinations	1042 (100)
Total no. of biopsies advised [a]	20 (1.9)
Total no. of biopsies performed [b]	14 (1.3)
Patient adherence [c]	13 (65)
Total no. of detected cancers [d]	11
Cancer diagnosis rate / 1000	10.6
Type of tumor detected on biopsy, n = 14	
Invasive ductal carcinoma	7 (50.0)
Ductal carcinoma in situ	2 (14.3)
Invasive lobular carcinoma	1 (7.1)
Unknown malignancy [e]	1 (7.1)
Benign breast lesions	3 (21.4)
Nodal positivity, n = 11 [f]	
Yes	3 (27.3)
No	8 (72.7)

[a], For BI-RADS 4 and 5 lesions only (n = 20); [b], Including BI-RADS 3, 4, and 5 lesions (n = 14); [c], Calculated for BI-RADS 4 and 5 lesions only (n = 20); [d], Based on histopathological confirmation of malignancy; [e], Biopsy was performed at an outside institution, the complete record of the type of cancer could not be acquired; [f], Nodal positivity is only for malignant lesions (n=11); MMU, Mobile Mammography Unit

However, only 13 out of 20 pursued it till the last follow-up calls in 2023. Therefore, the patient adherence rate was 65%. One patient with BI-RADS 3 lesion underwent biopsy on self-request based upon her strong family history which came out to be benign. A total of 11 cancers were diagnosed out of 14 biopsies (78.6%) leading to a CDR of 10.6 patients per 1000 (11 out of 1042). Invasive ductal carcinoma (IDC) was the most detected cancer making up 63.6% of the cancer diagnoses (7 patients), followed by ductal carcinoma in-situ (DCIS) in 2 patients (18.2%) and invasive lobular carcinoma (ILC) in 1 patient (9.1%). One patient underwent biopsy and subsequent oncological management from an outside institution and was not aware of the type of cancer. Benign breast lesions made up 21.4% of the biopsy findings (Table 3).

Among women who underwent biopsy, BI-RADS category 3 accounted for one case with benign outcome. In BI-RADS 4 lesions (n=19), 10 (90.9%) were malignant, 2 (9.1%) were benign, and 7 had unknown outcomes with

Table 4. Distribution of BI-RADS Classification and Histopathological Diagnosis based on Biopsy

BI-RADS assessment	malignant		Benign		Unknown	
	n	%	n	%	n	%
3	0	0.0	1	33.3	0	0
4	10	90.9	2	66.7	7	100
5	1	9.1	0	0.0	0	0.0
Total	11	100	3	100	7	100

BI-RADS 3, PPV 0%; BI-RADS 4, PPV 83.3%; BI-RADS 5, PPV 100%. PPV, Positive Predictive Value; BI-RADS, Breast Imaging-Reporting and Data System

Positive Predictive Value (PPV) of 83.3%. One BI-RADS 5 lesion was identified and confirmed malignant (PPV – 100%) (Table 4).

Discussion

This study is the first of its kind conducted in Pakistan which evaluates the performance indicators of an MMU used as part of a low-cost breast cancer screening program. We employed AIR and CDR as metrics to measure the performance of our MMU screening program since these are the most clinically efficient and cost-effective methods [10].

We observed a notably high AIR due to suspicious findings or dense breast (65.5%). This exceeds standard benchmarks (ACR guidelines recommend 5–12% recall) and reflects our patient population and screening approach [11]. Recall rates generally vary around the world with reports ranging from 2.3% to 19.9% [12-14] and is additionally shown to have a higher rate at an MMU than at fixed clinics (16% vs. 13%) [9, 15]. Our higher rate is probably due to a dense-breast population along with the CR system within the MMU that encourages more cautious assessment and the preponderance of first-time screeners. Higher AIR does not cause a significant gain in the CDR, but it can increase the false-positive examinations and patient anxiety in addition to the cost of screening in our context [15, 16].

Our results were significantly impacted by breast density. In line with our relatively young population screened at the MMU, almost two-thirds of women had dense or heterogeneously dense breasts. Lesions may be concealed by dense tissue, resulting in a high percentage of BI-RADS 0 evaluations (64.5% in our study). In a comparable mobile screening effort in India (Chiraiya), 33% of screened women required additional imaging (BI-RADS 0), and benign findings predominated in 49% (BI-RADS II) [17]. We addressed density by recommending supplemental ultrasound for women with heterogeneously or extremely dense breasts. Despite this, 232 (37.2%) of patients who were advised ultrasound did not pursue it, rendering their screening incomplete.

Following abnormal screening, follow-up adherence in our study was suboptimal. One-third of potentially suspicious cases remained unconfirmed, with only 13 out of 20 women (65%) who were advised to have a biopsy completing it. The institution tried contacting the women who were advised additional testing; however, a third of the participants were unreachable or did not get their testing done. The Chiraiya study also lost about one-third of BI-RADS 0 patients to follow-up [17]. In environments with limited resources, loss of follow-up is a frequent problem. In our cultural context, barriers such as fear, stigma, financial constraints, and limited awareness likely contributed to dropouts. This may have contributed to an underestimation of the true CDR. Future initiatives should include patient navigation, reminder systems, and local counselling to close these gaps and increase adherence.

The CDR per 1000 from across the globe has also been quite variable (3.6 to 16 per 1000) [18]. The CDR from our study was 10.6 per 1000 and is on the higher end. Importantly, majority of diagnosed malignant lesions had no nodal involvement (72.7% vs. 27.3%). A similar finding was presented by Barth et al. where most of the breast cancers found on screening were node-negative, thus diagnosed at an early stage [19]. Early detection of node-negative breast cancer is the main goal of screening, as it significantly improves prognosis and allows for less aggressive treatment [20]. In our cohort, 14.3% of cancers were DCIS that might not become clinically apparent until later. Identifying these on screening can prevent progression.

It is beneficial for drawing comparisons with other MMU programs. Mobile units have been successful in reaching underserved, high-risk communities in high-income environments [20]. A study from New York City on 32,350 participants found that mobile mammography participants were predominantly low-income, minority, or uninsured women, similar to our cohort [20]. These programs also identified issues with follow-up; to increase attendance and adherence, they promoted patient navigation and customized communication [20]. Our results confirm that the mobile unit increased access and detected cancers, but at the expense of increased recall rates and some loss to follow-up.

From a public health perspective, our results underscore the value of mobile screening in LMICs. Pakistan has one of the highest rates of breast cancer incidence in Asia and very poor survival due to late detection [21]. Mammography screening has been shown to reduce mortality in a population by approximately 15–56% [22]. MMU screening can improve participation and reduce geographic and social disparities, with potential cost-effectiveness in remote and deprived areas [23]. By providing service to communities, the MMU model can assist in overcoming cultural and access challenges. MMUs should be partnered with community education, seamlessly connected to treatment facilities, and culturally customized (e.g., with female staff and local language materials) to maximize its impact.

Due to the COVID-19 pandemic, participation for screening at the MMU was lower than anticipated and the program was shortly closed thereafter for the same reason, which was one of the study's shortcomings. Additionally, the CR system used for screening during the period soon became outdated and had to be discontinued. Patient-related factors that resulted in lower-than-expected involvement in our study were fear, stigma associated with the diagnosis, and poor socioeconomic circumstances [21]. Moreover, for additional images, patients had to visit the main tertiary care hospital which was cumbersome for majority of the women. The process was further hampered by a lack of qualified female technicians who were conversant in the local language and culture. Although the MMU provided significant benefits by offering low-cost and rapid access to screening, the unit itself was large, brittle for the roads, and required highly qualified technical personnel for maintenance. Its mobility and relocation to rural locations with inadequate road infrastructure were restricted by these limitations. Despite of all the obstacles, this study is one of the first and largest to successfully examine screening outcomes of women accessing the low-cost screening MMU set up in Pakistan. It is also the first to evaluate an opportunistic screening program in the country based on performance indicators. This project serves as a valuable learning experience in developing a sustainable screening program aimed at early detection of breast cancer for women in our part of the world.

In conclusion, MMU provides accessible, affordable, convenient, and culturally sensitive breast cancer screening service, especially for addressing health disparities in women from underserved population. The increased use of MMUs can be an ingenious solution to the current state of reduced screening among women from far flung areas who have a mortality rate due to late diagnosis. High recall rate in breast cancer screening needs to be addressed with combination of quality improvement and standardized practices. Patient education and ongoing audit of recall patterns support continuous improvement while maintaining diagnostic safety. To promote early detection of BC, we need to develop region-specific evidence-based screening guidelines and improve public outreach screening programs.

Author Contribution Statement

SZ, GS, and US conceived and designed the research project. DA, AG and NI were involved in data acquisition, cleaning and follow-up of patients. US, DA and AG performed the statistical analysis. SZ, GS, DA, and AG contributed to drafting and revising the manuscript. SZ, GS, SA and KK provided expert input as subject specialists. SZ, GS, NI and US assisted in critical revision and editing of the manuscript. All authors reviewed the final version, approved it for submission, and took responsibility for the integrity of the work.

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Declaration of Conflicting Interests

The authors declare that there is no conflict of interest.

Ethics approval and consent to participate

The ethical approval was obtained by the Ethical Review Committee of Aga Khan University Hospital AKUH (ERC # 3350).

Availability of data and materials

The datasets used and analyzed during the current study will be available on reasonable request.

Abbreviations

BC: Breast cancer
MMU: Mobile Mammography Unit
AKUH: Aga Khan University Hospital
AKHWK: Aga Khan Hospital for Women Karimabad
AKMCCC: Aga Khan Maternal and Child Care Center
CR: Computed Radiography
PACS: Picture Archiving and Communication System
BI-RADS: Breast Imaging-Reporting and Data System
ACR: American College of Radiology
CDR: Cancer detection rate
AIR: Abnormal Interpretation Rate
SPSS: Statistical Package for Social Sciences
ERC: Ethical Review Committee
IQR: Interquartile range
OCP: Oral Contraceptive Pills
HRT: Hormone Replacement Therapy
IDC: Invasive Ductal Carcinoma
DCIS: Ductal Carcinoma in-situ
ILC: Invasive Lobular Carcinoma
PPV: Positive Predictive Value
LMIC: Low-middle-income countries

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