

The Role of Mobile Van Mammography Supported by Teleradiology in the Early Diagnosis of Breast Cancer: An Innovative Approach to a Growing Public Health Problem

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ABSTRACT

Cancer is a leading cause of death in women, accounting for 14% of cancers in Indian women. Reduction in mortality rates is contingent upon early diagnosis. Mammography is established as a diagnostic modality that ensures early detection of breast cancer. With the aim of promoting early diagnosis of breast cancer. The Poornasudha Cancer Foundation, a registered non-profit organization and Teleradiology Solutions, Bangalore, a teleradiology service provider collaborated together. 'MOM Express', (Mobile on-site Mammography) a bus equipped with mammography equipment provides mammography facilities to the women of rural and urban areas of Karnataka. DICOM images of mammograms were electronically transmitted by technologists from the Poornasudha mammography van to experts at a teleradiology reporting hub in Bangalore. Over a period of 4 years beginning September 2018, 2888 studies were interpreted via teleradiology. Women from rural and urban areas of Karnataka were included in the study. The mean age of the participants was 49.80 years (8.83 SD) confidence interval CI (95%) (50.12–49.47). The mean turn-around-time (TAT) for the report to reach the Poornasudha mammography vans once the images had been received was 12.74 hours (CI 95%: 13.15 – 12.34). The importance of mammography lies in the early diagnosis of breast cancer at an early stage of the disease before it has progressed with distant metastasis, which allows for an effective treatment strategy with an enhanced prognosis for long-term survival. In the setting of radiologist shortages, teleradiology provides a solution that allows for timely reporting of mammograms in a screening environment. This study highlights the role of teleradiology in the early detection of breast cancer in India.

Keywords: Healthcare, Mammography, MOM Express, Poornasudha, Teleradiology.

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INTRODUCTION

Cancer is a leading cause of death and a prime obstacle to increasing life expectancy globally.¹ Among all, breast cancer is the most prevalent cancer in women, accounting for 13.5% of cancers in Indian women.² Alarmingly, a woman is diagnosed with breast cancer in India every 4 minutes, and one dies of breast cancer every 13 minutes.³ According to GLOBOCAN 2020, breast cancer has exceeded lung cancer as the most frequently diagnosed cancer, with an estimation of 2.3 million new cases (11.7%) and 684,996 new deaths (6.9%) globally.⁴ In 2020, The National Cancer Registry Programme Report released by The Indian Council of Medical Research (ICMR) and National Centre for Disease Informatics & Research (NCDIR), Bengaluru, anticipates that cancer cases may likely

increase to 15.7 lakhs by 2025, following the current trends.⁵

Breast cancer results from uncontrolled rapid growth and cell division in the breast. It may spread to regional lymph nodes and eventually to other tissues including distant sites in the lungs, liver, bones, and brain. Early detection is of utmost importance in order to achieve complete cure and lower healthcare costs. If detected early, surgery, medications, and radiation therapy can efficiently treat the disease.

Conventionally, the early detection method has been breast self-examination or examination by a doctor at an annual medical check-up. But currently, mammography, one of the imaging techniques, is the standard screening and diagnostic procedure for breast cancer. A safe and acceptable low dose of radiation (20–30 keV), is used without causing supplemental

radiation risk.⁶ Two images of each breast are created under compression which prevents movement that can blur the image as well as reduces the degree of overlap of tissues, thus bringing out an image of better clarity.⁷ While mammography is the screening modality of choice for breast cancer, other diagnostic procedure are ultrasonography and MRI.

Today, in India, most breast cancer cases are unfortunately diagnosed at a later stage of its growth i.e. stages 3 and 4.² The ICMR/WHO national breast cancer management protocols are yet to be executed on a country-wide scale. Lack of governmental or nongovernmental support for an organized breast cancer screening program, inadequacy of diagnostic assistance, paucity of radiologists and generally biased attitude toward the health of females in the predominantly patriarchal Indian society are major obstacles to the early diagnosis of breast cancer.⁸ Moreover, illiteracy and lack of awareness among Indian women, and financial constraints are other deterrents to getting timely advice and treatment.⁹ We followed the guidelines of the American Cancer Society wherein a woman between 40 and 54 years should have a screening mammogram every year. Women 55 and older can switch to a mammogram every other year or can choose to continue yearly mammograms as long as in good health.^{10,11} The only exception was women with palpable breast lesions where as a result of the non-availability of the ultrasound, mammography was used as a diagnostic test.

Teleradiology is one method of ensuring that a large-scale mammography screening program is effectively supported by accurate radiologic diagnosis and made accessible to every woman whether in urban or rural locations in India. Teleradiology enables patients in one location to avail of reporting services without having to travel to distant locations and hence saving time and treatment costs.

With the aim of promoting early diagnosis of breast cancer, Teleradiology Solutions, Bangalore, a teleradiology service provider collaborated with The Poornasudha Cancer Foundation, a registered non-profit organization working towards early detection of cancer. Poornasudha Cancer Foundation has developed ‘MOM Express’, (Mobile On-site Mammography) a mobile unit equipped with traditional mammography equipment. The bus, custom-made for the purpose, has a lead lining as per regulations to prevent the low-intensity radiation from penetrating outside the van and ensure shielding the individuals in the vicinity.¹² It has a reception area, an examination room, and a space where the mammography machine, RS Mammomat 3000/Nova is mounted (Figure 1a and 1b).¹³ The goal of MOM Express is to provide a simple, accessible, economical doorstep screening opportunity. The NGO also organizes awareness camps dedicated to community outreach and breast care education in specific localities before the bus reaches the area. The camps are being organized both in rural as well as in urban areas such as outside churches, schools, colleges, central jail, the high court, and also with the Indian Airforce Wives Welfare Association (AFWWA). The MOM express has carried out mammographies at different locations



Figure 1: a. MOM Express (Mobile On-site Mammography) Van by Poornasudha Cancer Foundation. b. Mammography machine, RS Mammomat 3000/Nova

not only in Karnataka but also a few in other states such as Andhra Pradesh, Maharashtra, Kerala, and Tamil Nadu.

In the Indian healthcare sector, teleradiology services can ameliorate the shortage and availability of expert Mammography readers and enhance outcomes of patient care in remote locations. It contributes toward increasing longevity while improving access and lowering costs. This study aims to reflect the role of teleradiology in the early detection of breast cancer which is one of the leading causes of death among women in India.

METHODOLOGY

This study was carried out from September 2018 to April 2022 and involved the collaboration between Teleradiology Solutions and Poornasudha Cancer Foundation, Bangalore. In this study, mammography was performed by trained female mammography technicians in MOM Express mobile van. Both breasts were radiographed in craniocaudal and mediolateral oblique views with compression, using a computed radiography (CR) system. The DICOM images of the mammograms of patients were uploaded onto ‘RADspa’, a cloud-based Radiology Information System (RIS)/ Picture Archival and Communication System (PACS) system over a high-speed internet connection, generating a worklist (Figure 2). RADSpa is an electronic telereporting workflow platform.

The images were read and interpreted by radiologists empanelled with Teleradiology Solutions and the reports were transmitted back to Poornasudha mammography van over the same workflow platform (Figure 3). The reports were downloaded and communicated to the patients either through email (in the case of urban patients) or individually distributed

Status	Hospital	MRN	Mo	Procedure	Img #	Arrival time
Ready to Read	Poornasudha Cancer Foundation	300420223	MG	Breast: Bilateral	0/4	22/5/04 07:01 A
Ready to Read	Poornasudha Cancer Foundation	300420216	MG	Breast: Bilateral	0/4	22/5/04 07:01 A
Ready to Read	Poornasudha Cancer Foundation	300420217	MG	Breast: Bilateral	0/4	22/5/04 07:01 A
Ready to Read	Poornasudha Cancer Foundation	300420215	MG	Breast: Bilateral	0/4	22/5/04 07:01 A
Ready to Read	Poornasudha Cancer Foundation	300420239	MG	Breast: Bilateral	0/4	22/5/04 07:02 A
Read in Progress	Poornasudha Cancer Foundation	010520202	MG	Breast: Bilateral	0/4	22/01/05 12:08 A

Figure 2: Worklist of MG cases in RADspa at Teleradiology Solutions.

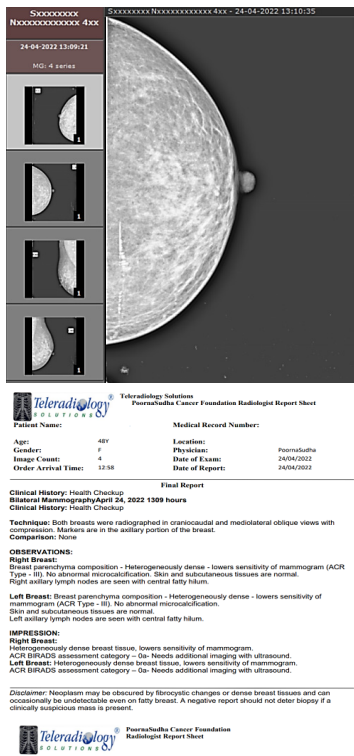


Figure 3: DICOM image of the mammogram uploaded in RADspa and the final report.

to them (in the case of rural patients) by the staff of Poornasudha Cancer Foundation or by community health workers/ ASHA (Accredited Social Health Activist) workers of the Anganwadi/ sub-centre/primary health centers at the location. The ASHA workers also explained the meaning and significance of the report findings to the patients and communicated the need for follow-up.

In order to guide and standardize the interpretation of mammograms among radiologists and referring physicians in the breast cancer diagnostic routine, The American College of Radiology (ACR) has established the Breast Imaging Reporting and Database System (BI-RADS™).^{14,15} Radiologists refer to each BIRADS category as a “level.” BI-RADS Assessment Categories:

- Category 0 Need Additional Imaging Evaluation
- Category 1 Negative
- Category 2 Benign Finding
- Category 3 Probably Benign Finding – Short Interval Follow-Up Suggested
- Category 4 Suspicious Abnormality – Biopsy Should Be Considered
- Category 5 Highly Suggestive of Malignancy – Appropriate Action Should Be Taken.
- Category 6: Known Biopsy-proven Malignancy - Appropriate Action Should Be Taken.

While interpreting the mammogram, the radiologist assigned a BIRAD score/ category according to the finding. In cases where there was an abnormality in the result (Category 4 or above), the patient was referred to a higher center for management.

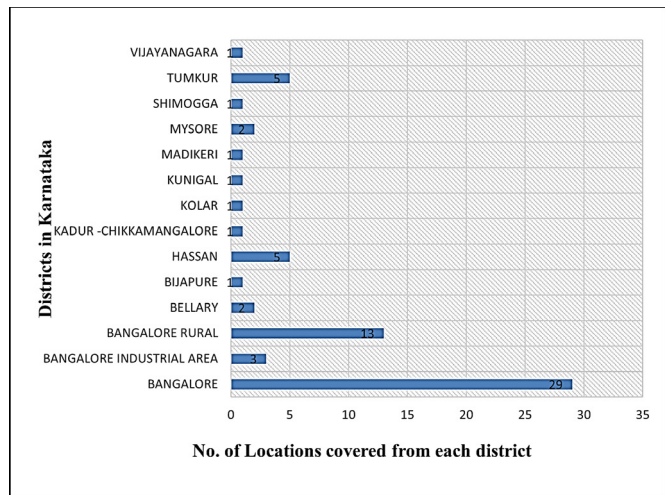


Figure 4: A comparative plot of the number of locations in different districts of Karnataka where mammography camps were conducted by MOM express.

RESULTS

Over a period of 4 years, a total of 2888 studies were performed in the Poornasudha mammography van at 72 locations from 5 states in Southern India and uploaded onto “RADspa”, a cloud-based Teleradiology reporting platform over which images were transmitted to radiologists of Teleradiology Solutions. The mammography camps were conducted at 66 locations in different districts of Karnataka, at 3 locations in Andhra Pradesh, and 1 location each in Kerala, Maharashtra, and Tamil Nadu (Table 1). Among Karnataka, mammography camps were conducted with a maximum of 29 locations in Bangalore (Figure 4). No mammography camps were conducted during the Covid -19 pandemic. 29 radiologists of Teleradiology Solutions, with relevant certification and medical licensure residing at different locations in India such as Bangalore, Bhopal, Chennai, Delhi, Hyderabad, Mumbai, and from the diaspora outside India (Australia, Saudi Arabia, Singapore, and USA) interpreted the cases (Figure 5).

The age of subjects in this study ranged from 35 years to 84 years but a small number of exceptional cases between 21 to 34 years of age volunteered for mammographic evaluation due to prior abnormal palpable findings (given that sonography was not available in the mobile van setting). The mean age was 49.80 years (8.83 SD) confidence interval CI (95%)

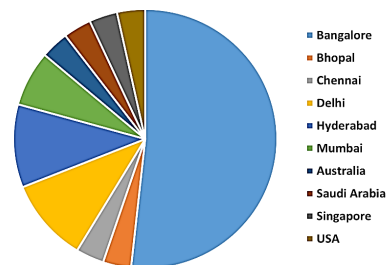


Figure 5: A comparative plot of radiologists telereporting from different locations of India and abroad.

Table 1: The list of locations where MOM Express van conducted mammography camps.

State	City	Location				
Karnataka	Bangalore	Hegganahalli	Bellary	Nelamangala		
		J C Nagar		Dobbaspete		
		Yeshwanthpura		Bellary		
		Indira Nagar		Kampali		
		Hebbal		Bijapure	Katakanahalli	
		Rajajinagar		Hassan	Mani Hospital	
		Aralikere			Karle Hassan	
		Parappana Agrahara			Rotary Arehalli	
		Nandini Layout			Dr.Savitri	
		Basaveshwara Nagar			Kabligere	
		Prakash Nagar		Kadur -Chikkamangalore	Astinapura	
		Vasanth Nagar			Mulabagilu	
		Siddapura		Kolar	Magadi	
		Lakshmi Devi Nagar		Kunigal	Kushal Nagar	
		Yelahanka		Madikeri	Mandya	
		Kamakshipalya	Mysore	C R Patna		
		Basaveshwara Nagar	Shimogga	Lion Club		
		Madiwala		Honavalli		
		HBR Layout		Gubbi		
		Nandini Layout	Tumkur	Pavagada		
		AIWC		Madhugiri		
		True Well Hospital J C Road	Vijayanagara	Chithradurga		
		Banashankari		Hospet		
		J.P Nagar	Andhra Pradesh	Chitture		
		Devanahalli		MLL Hospital		
		Rajajinagar	Kerala	Nellore		
		Electronic City		Kozhikode		
		B T M Layout	Maharashtra	Butibori		
		Malleshwaram		Nagpur		
		Bangalore Industrial Area	Bangalore	Laggere	Tamil Nadu	Chennai
				Ganapati Nagar (Peenya)		Kannadapalyam
				Hegganahalli (Peenya)		
				Kanakapura		
Nagasandra						
Mallasandra						
R R Nagar						
Maralawadi						
Kengeri						
Maralawadi						
Bangalore Rural	Bangalore	Reddihalli Devanahalli				
		Kallankuppe(Maralawadi)				
		Tooksandra(Maralawadi)				
		Doddaballapur				

(50.12 - 49.47). The median age of the women at the time of mammography was 48 years. A maximum number of studies (61%) were between 35 and 50 years of age (Figure 6). Out of 2888 cases, maximum number of studies (52.5%) belonged to BIRADS assessment category 0. 39% cases were interpreted to be in category 1. The BIRADS assessment category 2 and 3 had 239 and 9 cases respectively. 2 cases were from category 4 (Figure 7).

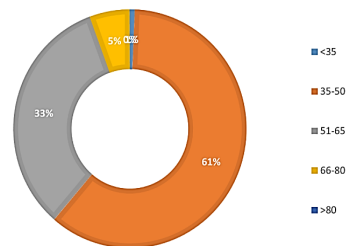


Figure 6: A comparative plot of the total number of studies in different age groups.

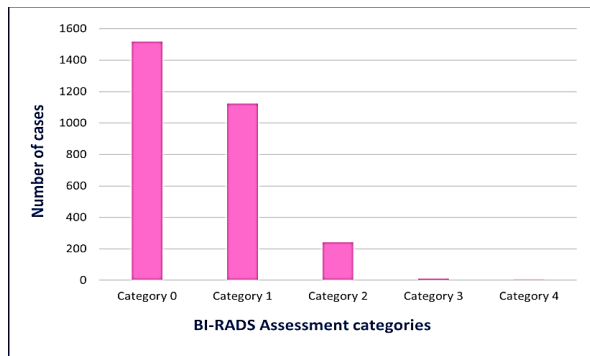


Figure 7: A comparative plot of the total number of studies belonging to different BIRAD assessment categories.

The mean turn-around-time (TAT) for the report to reach the Poornasudha mammography van once the images had been received was 12.74 hrs (95% confidence interval [CI]: 13.15 - 12.34).

DISCUSSION

According to a report, there are approximately 15,000 radiologists currently for a population of 1.3 billion in India, and most are concentrated in the metro or Tier I cities. This corresponds to a ratio of approximately 1 radiologist for 100,000 population as compared with 1 for 10,000 in the United States.¹⁶ The shortage and unavailability of radiologists leave many sections of society inaccessible to radiology services. This is of importance especially in the context of breast cancer mass screening programs, as it results in late detection and may ultimately lead to an economic burden on the national health programs. Teleradiology can be a game-changer in such situations by not only providing rural/tribal patients located in remote locations access to radiologists practicing in urban locations but also addressing the issue of costs and travel time. In our study, 29 radiologists from different locations in India like Bangalore, Bhopal, Chennai, Delhi, Hyderabad, Mumbai, and from the diaspora outside India (Australia, Saudi Arabia, Singapore, and USA) teleported studies from 66 locations within Karnataka, 2 locations from Andhra Pradesh and 1 location each from Kerala, Maharashtra and Tamil Nadu. (Figure 4, 5). The vast majority of studies were performed between the ages of 40-60 years (Figure 6). The decrease in the number of cases of the latter age could be due to lower rates of access to screening in the elderly population.¹⁷ Our data interprets that the median age of the women at the time of mammography was 48 years. This is likely related to the fact that the MOM express van conducted mammographies at work locations like colleges, courts, institutions, etc where most of the women were in the 40s age group.

According to the ACR, the BI-RADS™ system is intended to assist radiologists and referring physicians in the breast cancer decision-making process for patient care management. BIRADS score/categories were assigned according to the findings. The mammographic findings that are characteristic of malignancy include clustered microcalcifications, irregular

spiculated lesions, asymmetric densities, architectural distortion, and nipple retractions.¹⁴ In our study, the majority of the subjects (1516) had no abnormal findings. In some cases, scattered punctate calcifications were observed (Figure 7). Further, heterogeneously dense breasts have more glandular and connective tissue than fat tissue which lowers the sensitivity of the mammogram. In our study, the maximum number of women were in the age group of 40 to 60 years who had heterogeneously dense breasts. Therefore, ACR BIRADS assessment category 0 was given which means additional imaging with ultrasound is needed. Category 0 is a temporary category which means additional imaging is needed before assigning a permanent BI-RADS™ assessment category.

The 39% of all mammograms with no evidence of focal mass lesion, abnormal calcification, or any architectural distortion were classified as BIRADS Category 1 i.e. negative for any cancerous findings. There is a 5/10,000 chance of cancer being present. Continued annual screening mammography (for women 40 and older) was recommended as per standard of care.¹⁵

239 mammograms were interpreted to BIRADS category 2 with benign (non-cancerous) findings (No dominant masses or suspicious calcifications or architectural disturbances were present) and suggested annual follow-up. Nine studies that were marked BIRADS category 3 showed a predominantly well-defined soft tissue density nodular lesion at a particular depth from the skin and with smooth lobulated margins. Dense internal calcifications were also seen. BIRADS 3 lesions are considered probably benign with a malignancy risk of <2%. Such cases were suggested to undergo additional imaging with ultrasound and a follow-up after a short interval. The mammograms of two cases in which a few lesions were seen with microcalcific clusters were classified as BIRADS category 4. The probability of these lesions being malignant is high and a minimal invasive biopsy is recommended as per standard of care.¹⁴

While interpreting mammograms, radiologists and clinicians also considered patient demographics and other information such as the familial history of breast cancer, any medication or radiation exposure, lack of breastfeeding, etc to analyse other risk factors for breast cancer. Thus, the women under study were asked to fill out the consent forms with these details before the mammography test was done (Figure8). The risk of breast cancer increases with age. Since breast cancer is the most prevalent cancer type in Indian women, women in their early 30s till 50s are at low to moderate risk to develop breast cancer, and the incidence risk attains its peak at 50–60 years of age. Another factor predisposing to higher incidence of breast cancer in the younger age group is familial history. A woman's risk for breast cancer increases if her mother, sister, or daughter (first-degree relative) or multiple family members on either maternal or paternal side of the family have been diagnosed with breast or ovarian cancer. Some of the earlier studies also interpreted that almost one-third of all breast cancer patients have a history of this disease in their



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 E-mail : coordinator.pscf@gmail.com \ www.poornasudha.org

CONSENT FORM

Name: _____
 Age: 41 Date of Birth: _____
 Address: S V S Sinagar
 Telephone Mobile: _____ Residence: _____
 First day of LMP: 08-07-2022 Do you have Breast Implant: No

Breast Cancer	Mammography	
Screening group	Kannada	
Mother tongue	Graduate	
Education	Home Maker	
Occupation	Married	
Marital status	No	
Anyone in your family have/had cancer	No	
Have you undergone hormone therapy?	No	
Have you ever used oral contraceptives?	5.5	
Hour height(in Ft)	75	
Your weight(in kilograms)	Medium	
Size of your breast:	No	
Do you drink alcohol?		
How often you drink?		
Do you smoke?	Moderate	
Are you physically active?	Non-Vegetarian	
Are you	No	
Have you done Mammography earlier?	20 to 29	
Age at Marriage:	1 to 2	
Number of children:	20 to 29	
Age at first child:	12+	
How long you breast-fed the first child?	20 to 29	
Age at second child:	12+	
How long you breast-fed the second child?		
Age at third child:		
How long you breast-fed the third child?	10 to 13	
Age at menarche:	No	
Have you had menopause?		
Clinical Information		
Patient symptoms:	Cough	
Do you have a New Lump?	No	
Any Nipple Discharge?	No	
Any Nipple changes?	No	
Do you have Breast Pain?	No	
Any skin changes?(Redness/Rashes)	No	
Comments:		

Figure 8: The consent form to be filled out by the woman before the mammography test.

families. The mutations in the BRCA1 and BRCA2 genes have been identified as the major cause of breast cancer.¹⁸ Further, it is also found that urban women (1 in 22) are more likely to develop breast cancer during their lifetime as compared to rural women (1 in 60).^{19,20}

In our study, the mean turn-around-time (TAT) for all the studies was 12.74 hrs (95% confidence interval [CI]: 13.15 - 12.34), which is highly satisfactory for a screening program. The diagnosis of breast cancer at an early stage of the disease before it has progressed or metastasized is paramount as it allows for the immediate aggressive treatment and improves prognosis for long-term survival. Furthermore, this permits less invasive treatment including breast conservation procedures leading to a better quality of life.⁷

The results of our study point towards the possibility of effective logistically viable mass population screening mammography through mobile units achieving rural outreach without increasing radiologist presence in these areas. The practice of teleradiology and telemedicine consultations teaming with mobile diagnostic and therapeutic units can revolutionize healthcare accessibility and affordability in developing nations such as ours. Policy planning by governments can simulate this model and generate more units of public-private partnerships of mobile diagnostic and therapeutic units serviced by teleradiology / telemedicine service providers for improving the rural population's accessibility to state-of-the-art healthcare facilities. Future research needs to focus on larger population studies with a focus on follow-up of patients with positive results and documentation of long-term benefits of early detection achieved by the mobile units. Research on

improving the inclusion of the older population in screening programs is also paramount as the geriatric and unemployed population is difficult to reach, even with the current mobile units. Improving diagnostic accuracy also depends on the availability of additional diagnostic procedures like mobile ultrasonography with possible image-guided histopathological sampling and diagnostic confirmation.

CONCLUSION

Breast cancer is today a prominent cause of morbidity and mortality among women. It is absolutely crucial to develop sustainable infrastructure and facilities for early cancer detection and care globally. Early diagnosis is important to combat this disease and bestows affected women with a fighting chance of survival. Poornasudha Cancer Foundation has brought mobile mammography services directly to all urban as well as rural women at the site where they live and work, helping them break cultural, financial, linguistic, and logistical barriers and making mammography examinations more accessible. Although, mammography is the screening investigation of choice for breast cancer, several mammography studies are inconclusive and need additional imaging, the commonest being Ultrasonography. If ultrasonography confirms the presence of a lesion, an ultrasound-guided fine needle aspiration cytology or biopsy can conclusively prove the presence of neoplastic breast disease. Although there are mobile Ultrasonography units available and can easily be installed in a mobile population screening unit such as ours, the statutory regulations of our geographical area prohibit the same (concern about the misuse of Ultrasonography for illegal fetal sex determination and selection). Relaxation of these regulations and having an ultrasound machine in the Mammography van with a limited superficial imaging (Ultrasound linear array probe centred at 7.5 MHz.) will definitely be a game changer, that could take breast cancer screening to the next level. Some of the patients with atypical appearing lesions may benefit from MRI evaluation of the breast. Patients with confirmed breast cancer would also need further whole-body screening for the presence of metastatic disease before finalizing the treatment plans. This is done using Contrast-enhanced CT and PET CT studies, Bone scans for osseous metastasis, and MRI study of the brain as indicated by the patient's clinical parameters.

Teleradiology Solutions, a teleradiology service provider, provides technology-based logistical support to mitigate the shortage of expert radiologists who can help in the early detection of cancer that can transform the outcome of patients, raising hope for a substantial change in its overall impact on the health and wellbeing of women. In the future, Deep Learning/ Artificial Intelligence algorithms such as, MammoAssist, an algorithm developed by TeleradTech, further can play a significant role in breast cancer screening programs to eliminate negative cases with a high degree of accuracy and categorize benign and malignant cases with a fully structured report including a BIRADS Score to ensure objective reporting and clear risk stratification.

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