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Original paper

# Improvement of early detection of breast cancer through collaborative multi-country efforts: Medical physics component

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## ABSTRACT

*Purpose:* The International Atomic Energy Agency (IAEA) through a Coordinated Research Project on "*Enhancing Capacity for Early Detection and Diagnosis of Breast Cancer through Imaging*", brought together a group of mammography radiologists, medical physicists and radiographers; to investigate current practices and improve procedures for the early detection of breast cancer by strengthening both the clinical and medical physics components. This paper addresses the medical physics component.

*Methods:* The countries that participated in the CRP were Bosnia and Herzegovina, Costa Rica, Egypt, India, Kenya, the Frmr. Yug. Rep. of Macedonia, Mexico, Nigeria, Pakistan, Philippines, Slovenia, Turkey, Uganda, United Kingdom and Zambia. Ten institutions participated using IAEA quality control protocols in 9 digital and 3 analogue mammography equipment. A spreadsheet for data collection was generated and distributed. Evaluation of image quality was done using TOR MAX and DMAM2 Gold phantoms.

*Results:* QC results for analogue equipment showed satisfactory results. QC tests performed on digital systems showed that improvements needed to be implemented, especially in thickness accuracy, signal difference to noise ratio (SDNR) values for achievable levels, uniformity and modulation transfer function (MTF). Mean glandular dose (MGD) was below international recommended levels for patient radiation protection. Evaluation of image quality by phantoms also indicated the need for improvement.

*Conclusions:* Common activities facilitated improvement in mammography practice, including training of medical physicists in QC programs and infrastructure was improved and strengthened; networking among medical physicists and radiologists took place and was maintained over time. IAEA QC protocols provided a uniformed approach to QC measurements.

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## 1. Introduction

In 2012, there were an estimated 1670000 cases of breast cancer diagnosed worldwide [1] making breast cancer the second most common cancer in the world and the most common cancer in women. According to the International Agency for Research on Cancer (IARC), over half of breast cancers occurred in the less developed countries. Incidence rates vary between regions, with the lowest rate in Central Africa (27/100000) and the highest in Belgium (111,9/100000). Deaths from breast cancer are disproportionately higher in less developed countries with 62% of total deaths occurring in these countries. As countries develop breast screening programs it is likely that breast cancer incidence rates will increase due to its early detection.

At the moment, X-ray mammography is the only technique that has proven the ability to detect breast cancer at an early stage, before the cancer is palpable and is the basis of the most organized breast screening programs to detect breast cancer in a non-symptomatic population. For mammography to be effective at detecting breast cancer at an early stage, adequate differentiation of small masses and microcalcifications is required, which in principle can only produce subtle contrast differences in mammography images. These imaging requirements place high technical demands on the imaging equipment and require high image quality and rigorous Quality Assurance (QA) to maintain these standards. Additional constraints are placed as the radiation dose should be kept at the lowest possible level, given the size average breast composition or average breast glandularity of the non-symptomatic target group, and the radiosensitivity of the breast. Routine performance testing of mammography imaging equipment by competent medical physicists is an essential component of a comprehensive QA program for mammography screening [2,3]. Additionally, it is apparent that all involved medical professionals have to be properly trained and highly acquainted with the mammographic procedure.

In 2012, the International Atomic Energy Agency (IAEA) started a Coordinated Research Project (CRP): *IAEA CRP E1.30.39 Enhancing Capacity for Early Detection and Diagnosis of Breast Cancer through Imaging,* which grouped together mammography radiologists, medical physicists and radiographers from 15 different countries. During the 4-year period of the project many activities were undertaken with the intention to investigate current practices, aiming to improve early detection of breast cancer by strengthening both the clinical and medical physics components. In this context, as part of the CRP activities participants received additional training in several components of the QA process. The overall objective of the CRP, from the Medical Physics perspective, was to contribute to the improvement in diagnosis and detection of breast cancer following the application of international standards of best practice in mammography. The CRP activities were specifically designed to: familiarize participants with the assessment of image quality and dosimetry requirements for mammography; training medical physicists and radiographers on performing measurements and collecting data, improving the provision of QA processes; collecting comprehensive Quality Control (QC) results in participating institutions using the relevant IAEA protocols; analyzing and evaluating these QC results and comparing them with internationally established requirements and tolerances for corrective actions [2,4]; evaluating image quality in mammography units in a standardized way, using a common phantom and centralized analysis of the images, and finally create a network of medical physicists and radiologists that can support each other on the technical aspects of mammography.

There are a number of differences between the IAEA protocol and that of the European protocol. The main difference is that in the IAEA approach, measurement of contrast detail performance uses the same test object, but with an automated reading system, which is how many individuals apply the EC test object/protocol these days. In addition, there are slight differences in the specification of the position for the test object for assessment of SNR values, but which would not cause there to be a significant difference between the IAEA protocol and that of the EC. The main difference is that the specifications for MTF measurements is more detailed in the IAEA protocol than in the EC's one.

## 2. Materials and methods

### 2.1. Participants

Countries participating in the IAEA CRP had very different levels of implementation of their breast screening programs and large deviations in the available mammography equipment and corresponding conformance with established quality assurance programs. To remove this local bias in terms of the level of QA implementation, and standardize the practices, all groups followed a common methodology for the QC test. IAEA Human Health Series No.2 [4] and No.17 [2] were agreed as references (for screen-film and digital mammography, respectively), allowing uniform collections of basic QC metrics and assessment of the performance of participating mammography equipment.

A total of 15 countries participated in different phases of the CRP (Bosnia and Herzegovina, Costa Rica, Egypt, India, Kenya, the Frmr. Yug. Rep. of Macedonia, México, Nigeria, Pakistan, Philippines, Slovenia, Turkey, Uganda, United Kingdom, Zambia), whereas 9 agreed to take part in this equipment testing inter-comparison. Table 1 shows information about participating institutes in terms of mammography equipment (analogue/digital), institution, existence of established screening program at the commencement of the CRP, number of clinical procedures during 2015 and implementation of organized QC programs before and after this CRP. Analogue equipment with its screen/film combination that participated in the study were: Planmed Nuance Classic (CAWO MAMMO R200/Kodak MIN R), Siemens Balance (Kodak MIN R 2000/AGFA HT) and Metaltronica Flat SE (Agfa HD Mamoray/

**Table 1**
Participating countries, institutions and procedures.

| Country | A | D | Institution/City | SC | Tomo | Bio | Procedures | QC Before | QC After |
|---|---|---|---|---|---|---|---|---|---|
| Bosnia and Herzegovina | | 1 | University Clinical Centre of the Republic of Srpska/Banja Luka | O | N | Y | 3168 | Y | Y |
| Costa Rica | 1 | 1 | Hospital Max Peralta/Cartago | O | N | N | 11882 | N | Y |
| Egypt | | 1 | Women and Fetal Imaging Centre/Cairo | O | N | N | 1403 | N | Y |
| India A | | 1 | Rajiv Gandhi Cancer Institute and Research Centre/Delhi | Y | Y | Y | 1760 | Y | Y |
| India B | | 1 | Institute of Nuclear Medicine and Allied Sciences/Delhi | Y | N | Y | 2174 | Y | Y |
| Macedonia | 1 | 1 | Faculty of Natural Sciences and Mathematics/Skopje | Y | N | N | 1560 | N | Y |
| México | | 1 | Universidad Nacional Autónoma de México/Cuidad de México | * | N | N | – | Y | Y |
| Pakistan | 1 | | Multan Institute of Nuclear Medicine and Radiotherapy/Multan | Y | N | Y | 1700 | Y | Y |
| Slovenia | | 1 | DORA Screening Programme/Ljubljana | Y | N | N | 39745 | Y | Y |
| Turkey | | 1 | Memeder, Istanbul | Y | N | Y | 3549 | N | Y |
| TOTAL | 3 | 9 | | 6 | 1 | 5 | | 6 | 10 |

*Notes*: A: analogue, D: digital, SC (screening program): Y (yes), O (opportunistic), *: no clinical use; Tomo: tomosynthesis Y (yes), N (no); Bio: stereotactic biopsy capability: Y (yes), N (no); Procedures: number of procedures done during 2015; QC Before: QC implemented before intervention and QC After: QC implemented after intervention.