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# Effect on quality assurance program and radiation dosimetry in ISO certified cancer hospital during the first COVID-19 wave

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## ABSTRACT

**Background:** Medical Physics department plays a pivotal role in developing and maintaining the quality services of radiation diagnosis and treatment in a cancer hospital. In this paper, the impact of the first COVID-19 wave on quality assurance (QA) program of medical physics department in an ISO-certified (9001-2015) hospital was quantified along with personnel dosimetry of radiation workers.

**Methods:** The number of monthly, quarterly, and annual quality control (QC) procedures was analyzed, and QA program was prioritized in nuclear medicine and radiology department depending upon the hospital needs during the pandemic. The effect on personnel dosimetry during COVID period and annual dose was measured.

**Results:** The QC procedures declined by 42% at radiological facilities (X-ray, mammography, gamma camera) of our hospital. It was noted that low frequency annual QC tests were less affected as compared to high frequency routine QC tests. During peak time of COVID-19 (23 March-30 June 2020) in Pakistan, the department worked with reduced manpower (50%) and reduced work hours (33%). The working hours gradually increased to 50% in June, 75% in August, and full restoration of manpower and workhours happened in September 2020. Radiation doses of all employees remained well within limit of 20 mSv per annum but the average dose of medical physics radiation worker increased during COVID.

**Conclusion:** COVID-19 has adversely affected quality assurance program. Care must be taken for all radiation workers as some employees may become overdosed due to radiation workload.

**Keywords:** Quality control, radiology, nuclear medicine, dosimetry.

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## Introduction

The first patient COVID-19 appeared in Pakistan in late February 2020 [1] while the first case of corona virus disease 2019 (COVID-19) appeared in Wuhan city of China on 8th December 2019 with pneumonia symptoms [2]. Coronavirus outbreak was declared as the sixth public health emergency of international concern on January 30, 2020 by World Health Organization (WHO) [3]. The same organization declared COVID-19 as a pandemic since March 2020 due to the rapid spread and severity of the disease [4]. Later, some patients had been diagnosed without fever, and without any radiological abnormality [5,6]. Out of several techniques developed for virus detection, only polymerase chain reaction (PCR) has been found the most popular method [7-10]. Therefore, all necessary precautions need to be taken in a hospital environment for infection control and transmission of the disease from one patient to others including employees working in allied health services. The COVID-19 pandemic has badly influenced healthcare services in radiology, nuclear medicine (NM), and radiation oncology, where suspected and confirmed COVID-19 patients visit frequently for diagnosis and treatment purposes [11,12]. Medical Physics department is not an exclusion to this because the physicists conduct and supervise quality assurance (QA) on medical imaging equipment and radiation treatment systems [13,14].

Medical Physicists form special group of radiation professionals who act as a bridge between clinical and technical areas. They follow national and international guidelines, legal obligations, and best practices [15].

They also tend to keep the radiation risks to minimum by following nationally and internationally accepted QA protocols and quality management programs on imaging modalities [13,14]. So, the presence of physicist and skilled technical staff ameliorates the quality of patients' diagnosis [13,15,16].

The quality communication and image transfer systems can help to draw expertise of remote radiologists and medical physicists. Internationally, Internet based technologies have helped physicists to work from home from image analysis to radiation treatment planning [15,17]. This is an area that has not been covered in the scope of this paper. However, the worsening situation due to COVID-19 requires medical physicist to align the radiation procedures of imaging for continuous delivery of essential services to community. Installation of new medical equipment, repair, or calibration has been badly affected in the pandemic due to reduced work hours, supply chain limitations, and air travel restrictions during lockdown conditions across countries [15]. In this situation, adapting to modified protocols advised by International Atomic Energy Agency (IAEA) and WHO has become imperative to control the transmission of the infectious severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) virus to work force while continuing radiation services to high-risk patients in cancer hospitals [18-20]. Earlier peer reviewed publications and experiences can help in this regard [16,21-23].

In comparison with other allied health professionals, medical physicists have indirect patient contact in various clinical departments. They can play a significant role to minimize risk of coronavirus infection in coordination with other departments [15]. Performing a quality control (QC) procedure on a contaminated medical equipment may be a cause of virus transmission from patient to health workers [24] even though patients and health workers followed the rules of social distancing, masking, and self-hygiene all over the workplace since the start of COVID-19. Therefore, radiation technologists made every effort to keep the radiological equipment in the hospital sanitized as per cleaning and sterilization instructions [25-27] and to prevent spread of virus due to QA tools. Here, we have reported the impact of COVID-19 conditions on the documented QA program of ISO certified (9001-2015) NM and radiotherapy institute of Pakistan. For this purpose, a priority for medical physics assignments was set for radiological modalities amid reduced availability of radiation workers in the hospital. The reason of reduced availability was to reduce employee's exposure to SARS-CoV-2 virus. The impact on personnel dosimetry was also measured during new working conditions.

## Methods

The medical physics department is a part of ISO 9001-2015 certified hospital and has a documented QA program based upon national and international guidelines provided by Pakistan Nuclear Regulatory authority (PNRA) and IAEA. In our hospital, the frequency of tests performed in 6 months period (pre-COVID period, July 19-December 19) was compared with the test frequency in the next 6 months period (COVID period, January 20-June 20). In our work, COVID period was started from January 20 because the disease came under serious attention of international community during that period when Pakistan still did not get any positive COVID case. A change in test frequency was documented to see the difference due to COVID-19 control measures. These QC tests determine the quality of imaging from radiological equipment. In this study, for personnel dosimetry, there is a slight change in the pre-COVID measurements (July 2019-November 2019) and in COVID period (December 2019-June 2020). The reason for this change is the schedule of thermoluminescence dosimetry (TLD) reading. The last batch was sent to national radiation dosimetry labs for reading purposes in November 2019, and the next turn was expected after 2 months. For each radiation worker, the pre-COVID and COVID radiation doses of 6 months were added. The cumulative absorbed dose (in millisievert) data was plotted against each worker. The cumulative dose of radiation workers, working in NM, radiology, oncology, general services department, medical physics, clinical and radioimmunoassay labs, and administration (sanitary attendants and drivers) was measured. In the same way, the impact of COVID-19 measures on annual personnel dosimetry was also calculated for all radiation workers working in the hospital. For this purpose, the dose records of year 2019 and 2020 were compared. This time the records of whole year for each radiation worker were collected in the form of absorbed dose (millisievert, mSv) and plotted graphically.

While performing daily QC of equipment, the NM nurse and radiation technologists were trained to use appropriate personnel protective equipment (PPE) and all antiseptic techniques to avoid virus transmission according to the guidelines of national (National Command and Operation Center) and international organizations (WHO) [1]. The special protocols for gloves removal, disinfection of devices, hand sanitization, and disposal of protective kits were adopted to contain virus transmission. Moreover, cleaning/house-keeping staff members were also trained to clean potentially contaminated surfaces after each contact with a suspected or high-risk patient. All the workers were formally inducted for PPE in the hospital.

The human resources were used on need basis. At the very start of COVID-19 lockdown, only one medical physicist was working on rotation basis for prioritized tasks. At later stages, medical physicists were divided into two groups. Each group was working on alternate weeks and the other group worked from home. For example, if the first group worked in the first week, then the second group was offsite. When the second group worked in the second week, the first group worked from home. None of the radiation workers is affected with SARS-CoV-2 virus during the first wave. However, there were a few suspicions of Coronavirus managed by allowing their stay at home. During this time, online meetings were also organized within medical physics department to complete ongoing assignments.

The lockdown conditions led to certain changes in the QA program, which have been detailed in Table 1. The procedures having significant impact on the quality of services, controlled imaging environment, or regulatory requirements of radiation protection were prioritized as essential assignment, whereas those having mild impact on the work environment are rated as non-essential services, see Table 1 for specific details.

The equipment such as X-ray field alignment tool, flood source phantom, Jaszczak Phantom, quadrant bar phantom, mammography phantoms, and other QC tools used for the above tasks were sanitized with 70%-80% ethanol [28] after use.

## Results

The reduced number of employees affected the QA program of the department. The number of working hours per employee was reduced to one-third except for essential workers who were directly dealing with patients. The same work scheme was applied to medical physicists. The impact on QC tests has been quantified (Figure 1). Daily QC tests were reduced by around 42% between COVID and pre-COVID period. The X-axis includes tests

***Table 1.*** *Priority setting in Medical Physics department running a certified QA program.*

| Sl. No. | Assignments/Duties | Priority level of QC test | Purpose |
|---|---|---|---|
| 1. | QC procedures of non-imaging NM equipment such as printers, temperature and humidity monitoring | Essential procedures | To maintain environment for high quality of imaging services |
| 2. | QC procedures of non-imaging radiology equipment like computerized radiography | Essential procedures | To maintain quality of services |
| 3. | Radiation protection | Essential procedures | To minimize occupational and medical exposures |
| 4. | Radiation dosimetry | Essential procedures | To monitor personalized dosimetry of radiation workers |
| 5. | Radioactive waste management activities | Biweekly | To monitor radiation waste production and to reduce radiation exposure in NM |
| 6. | Compliance of PNRA regulations | Essential procedures | To follow rules and regulations from local authority |
| 7. | Quality action teamwork and ISO documentation | Less frequent than normal | To follow quality management system and audit delay observed until 50% workers are restored |
| 8. | QC procedures of mammography | Essential procedure | To maintain image quality |
| 9. | QC procedures for ultrasound machines | Essential procedure | To maintain image quality |
| 10. | Maintain and update QC record | Essential procedure | To maintain QC records for future ISO audits |
| 11. | Teaching and training of radiation workers | Postponed/serviced online | To maintain academic projects and continuous education of the workers |
| 12. | QC procedures of dual head gamma cameras | Daily intrinsic uniformity was performed at low frequency | To maintain image quality |
| 13. | QC tests of dual energy X-ray absorptiometry (DEXA) scanner | Monthly QC | To maintain the quality of patient data |
| 14. | QC procedures on X-ray and computerized radiography (CR) system | Inspection tests were performed on each working day | To maintain image quality |
| 15. | Radiation survey of controlled area | On each working day | To maintain safe work environment |
| 16. | Radioactive source security and inventory | Strict locked conditions maintained | PNRA regulations |
| 17. | Personal dosimetry and annual health surveillance | Monitoring continued, but dosimetry services were stopped at national level | To monitor radiation dose and health conditions of radiation workers |
| 18. | Transportation of radioactive consignments, i.e. Technetium-99m (Tc-99m) generator and Iodine-131 (I-131) | Essential services (Initially, the services stopped due to lock-down conditions which were commenced later) | The orders were delayed internationally |
| 19. | QC procedures as per SOPs (standard operating procedures) of hot lab equipment, i.e. dose calibrator, gamma area monitor, and Tc-99m elution | Reduced frequency (The test frequency was reduced because of reduced manpower) | Only essential tests were performed |

(1) daily QC of X-ray unit and CR system, (2) CR unit assembly evaluation, (3) dose calibrator physical inspection, (4) dose calibrator auto zero, (5) dose calibrator chamber voltage, (6) dose calibrator background, (7) dose calibrator data check, (8) dose calibrator accuracy test/source deviation, (9) DEXA QA test, (10) DEXA physical inspection, and (11) radiation survey. The Y-axis gives the actual number of tests performed during pre-COVID and COVID periods.

Y-axis exhibits the number of tests performed in the given time period (see legend). X-axis represents QC procedures (1-11) Black continuous line with dots shows the normal frequency of daily tests and dotted line with orange dots indicates the frequency of tests affected by COVID-19 conditions.

The total number of QC tests performed during specified COVID and pre-COVID period were 1,439. They include QC procedures of gamma camera (GE Infinia, USA), gamma camera (Siemens ECAM, Germany), X-ray machine (GE Proteus XR/a, USA), DEXA-scanner (Hologic, USA), dose calibrator (CRC-25W, USA), radiation survey meter (Lamse 1001RD, Spain), mammography machine (Metaltronica Flatse, France), mammography machine (Hologic M-IV, USA), ultrasound machine (Esaote Mylab 30, Italy), ultrasound machine (Logic S8, USA). The breakup of daily, monthly, and quarterly tests is given in Table 2. It is noted that the low frequency tests were performed with better percentage (80%) during COVID period.

All the radiation workers of the institute had been using thermoluminescence dosimeters during pre-COVID and COVID periods. The impact of change in the number of

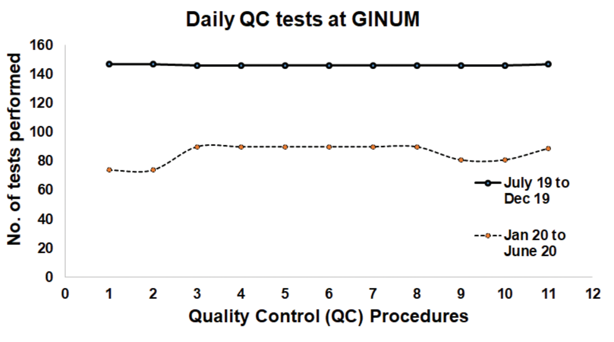


***Figure 1.*** *Effect on test frequency due to COVID-19.*

performed QC tests and reduced number of work hours in nuclear medicine institute was quantified indirectly by measuring annual personnel dosimetry of all radiation workers working in the hospital. For this purpose, the dose records of year 2019 and 2020 were compared along with the separate dose record comparison of pre-COVID and COVID period. The personalized dosimetry results for both periods are given in Figure 2a-h. X-axes represent the radiation workers of departments labeled with an abbreviation followed by the employee number. For example, ON, NM, GSD, MP, AD, RD, LAB represent oncology, nuclear medicine, general services department, medical physics, administration, radiology, and lab radiation workers, respectively. Y-axes show the dose absorbed in millisieverts by the worker. Figure 2a-h reveals that the annual personalized radiation doses for year 2020 are significantly lower than those for year 2019 for most of the radiation workers. The trend remains the same for all radiation workers in all departments.

Blue lines indicate radiation doses of worker for 6 months pre-COVID period of 2019, the green line indicates radiation doses of workers for 6 months COVID period of year 2020. The black line indicates radiation doses of workers for pre-COVID year 2019, and the red line shows radiation doses of workers during COVID period for the whole 2020 year.

There were 10 radiation workers from NM1 to NM10 in NM department. The doses of nuclear physicians NM2 and NM3 were marginally higher in the pre-COVID period, their absorbed dose decreased in the next 6 months of year 2020 leading to dose trend given in Figure 2b. A spike in the dose is noted for the technologist labeled as NM5 during the year 2019. A similar peak at NM5 employee was noted in the tenure July 19-November 19. The dose of NM10 was noted higher in year 2020 than 2019. It was because of his more radiation work in the department during COVID schedules. The dose received by medical physics technician marked as MP7 was relatively higher than the rest of the colleagues. It was because of his radiation workload that significantly increased while performing gamma camera scans of patients and routine QA (Figure 2c and 3). The trends of doses without MP7 are also given in Figure 2d. Interestingly, the annual doses of radiation worker working in Administration and Human Resources department marked as AD3 were

***Table 2.*** *Total number of tests performed during pre-COVID period and COVID period.*

| | Daily test[b] | Daily test[c] | Monthly test[b] | Monthly test[c] | Annual test[b] | Annual test[c] | Total annual tests performed |
|---|---|---|---|---|---|---|---|
| Frequency | 852 | 505 | 40 | 24 | 10 | 8 | 1,439 |
| Percentage of tests[a] | 59.27% | | 60% | | 80% | | |

[a]indicates the tests performed during COVID period (July-December 19) with respect to non-COVID period.
[b]indicates the period from July 2019 to December 2019.
[c]indicates theperiod from January 2020 to June 2020.

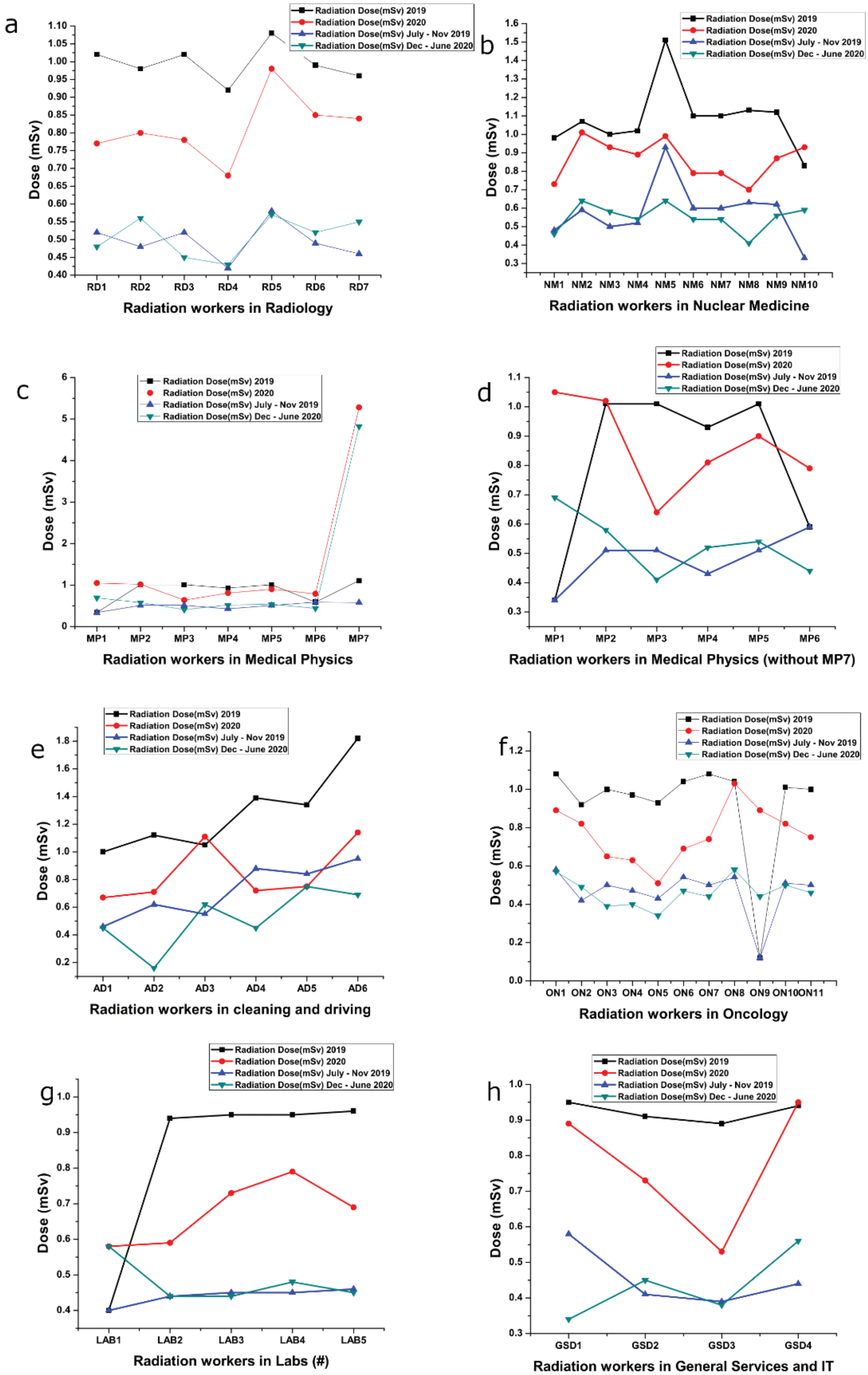


***Figure 2.*** *Comparison of TLD/personal dosimetry for 6 months and annual pre-COVID and COVID periods.*

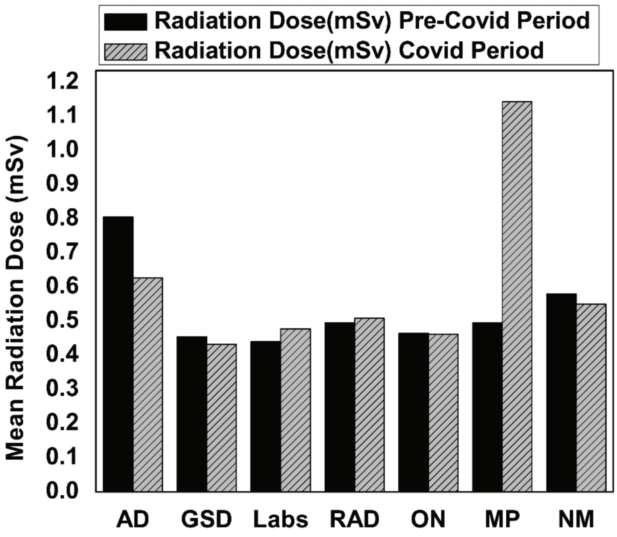


***Figure 3.*** *Average radiation dose for employees working in the different departments including AD, GSD, RAD, ON, MP, and NM.*

marginally different between years 2019 and 2020. Six-month doses also follow the same pattern (Figure 2e). In Oncology department, the radiation worker ON9 started career in late 2019. Therefore, the dose record shows a dip for that period (Figure 2f). The radiation workers of labs had clear lows during year 2020 in comparison with 2019 (Figure 2g), and the radiation dose of worker GSD4 in general services department of our hospital matched for year 2019 and 2020 (Figure 2h).

Average 6-monthly radiation doses from all workers of a department were not significantly different during COVID and Pre-COVID periods as shown in the bar graph (Figure 3). Only mean dose of medical physicists was higher during COVID period. The reason for the increase was the higher radiation dose of MP7 as illustrated in Figure 2c.

## Discussion

The Medical Physics work has been affected due to pandemic and the resulting lockdown conditions during year 2020. The total number of QC procedures declined by 42% for radiological facilities. It was noted that low frequency tests were performed efficiently as compared to other routine tests. Reduced number of radiation workers with reduced hours (33%) were presented which gradually increased to 50% in June and 75% in August, followed by routine working schedules in September 2020. The percentage of work hours was calculated from the number of days in which technical staff were officially assigned to be physically present at workplace during COVID-19 peak. All doses of workers remained within safe limit of 20 mSv per annum (Figure 2 and 3). Radiation technologists who were part of QA program were also directly involved in X-ray and gamma imaging of patients. They were more exposed and susceptible to contracting the Coronavirus [17]. Their long travel time between residence and workplace was also a source of exposure to SARS-CoV-2 virus. An accommodation inside hospital premises supported such staff to stay isolated whenever they had to travel over long distances before and after performing radiation duties. A shift conveyance was supporting their local travel safely on daily basis without using public transport. The local radiation workers, who were on daily roasters were advised to stay at home if they felt unwell to reduce the risk of infection transmission to other employees in the hospital.

During COVID, a minimum level of staff and resources helped to maintain a graduated delay of patient diagnosis and treatment keeping in view the safety, equipment resources, technical aspects, and patient contact probability [5,16,29]. In the post COVID situation, the radiation doses to workers are expected to rise due to increase in the number of rescheduled patient procedures [22]. However, the frequency of QA procedures will be restored to normal as per standards set in ISO documents. In our settings, the reduction in the number of QA procedures was also due to remote working, causing further drop in personal doses of radiation workers during year 2020 as compared to year 2019 (Figure 2). The COVID-19 lockdown and pandemic conditions provided opportunities not only to work remotely but also to engage with distant colleagues using social distance tools such as Zoom. While working on QA of imaging modalities, the Internet-based communication helped to coordinate with other colleagues, e.g., for QC procedures of ultrasound and mammography. Besides that, the digital media helped to communicate intradepartmental and interdepartmental meetings to continue discussions for the technical procurement processes and planning for equipment installations in new radiotherapy department of our cancer hospital such as linear accelerator, radiotherapy simulator, Co-60-unit, and CR machine.

NM department continued the registration of new patients for thyroid, renal, cardiac, and bone scans. Emergency patients were also catered at these facilities. These procedures (scans and therapies) were identified and prioritized for high risk (suspected or COVID positive) patients with reasonable protection, still the total number of patients decreased at gamma cameras. The frequency of daily extrinsic uniformity test for gamma cameras was reduced by 39% at GE Infinia gamma camera and by 34% at Siemens ECAM dual head gamma cameras. Some personnel radiation doses (Figure 2b,d,g) were found higher than others because some employees were preferred for duty over others to maintain radiation services in the hospital during COVID period. They were local employees who did not require any public transport for commute during lockdowns.

## Conclusion

The management of our cancer hospital worked proactively in pandemic control measures during the first wave of COVID-19. All radiation workers worked efficiently and safely with limited and constrained resources to maintain ISO certified services for visiting patients. The arrangement of resources for Medical Physics department and the development of schedules for radiation workers not only maintained radiation exposures under the safe limits but also kept the essential QA program intact for annual surveillance audit of ISO 9001-2015 of institute.

## List of Abbreviations

| | |
|---|---|
| AD | Administration |
| Covid-19 | Coronavirus Disease of 2019 |
| CR | Computerized Radiography |
| GSD | General Services Department |
| IAEA | International Atomic Energy Agency |
| MP | Medical Physics |
| NCOC | National Command and Operation Center |
| NM | Nuclear Medicine |
| ON | Oncology |
| PCR | Polymerase Chain Reaction |
| PHEIC | Public Health Emergency of International Concern |
| PPE | Personnel Protective Equipment |
| QA | Quality Assurance |
| QC | Quality Control |
| RAD | Radiology |
| RIA | Radioimmunoassay |
| SARS-COV2 | Severe Acute Respiratory Syndrome Coronavirus 2 |
| TLD | Thermoluminescence Dosimetry |
| WHO | World Health Organization |

## Conflict of interest

The authors declare that there is no conflict of interest regarding the publication of this article.

## Consent to participate

N/A.


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## Ethical approval

Not applicable.

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