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Balance of the External Dosimetry service of the LAF-RAM during the year of Covid19. Is there an incidence in the doses of TOE?

Andrea Marcela Castillo Arias
National Autonomous University of Nicaragua, Managua
Laboratory of Radiation Physics and Metrology (LAF-RAM)
https://orcid.org/0000-0001-6596-1177
acastillos@unan.edu.ni

Norma Alejandra Roas Zúniga
National Autonomous University of Nicaragua, Managua
Laboratory of Radiation Physics and Metrology (LAF-RAM)
https://orcid.org/0000-0002-8177-4731
nroa@unan.edu.ni

Ricardo Enrique Pérez Zeledón
National Autonomous University of Nicaragua, Managua
Laboratory of Radiation Physics and Metrology (LAF-RAM)
https://orcid.org/0000-0001-6602-6543
richperez1993@gmail.com

Josselyn Suyen Mendoza Korea
National Autonomous University of Nicaragua, Managua.
Laboratory of Radiation Physics and Metrology (LAF-RAM)
https://orcid.org/0000-0002-6023-6678
josselyn95mendoza@hotmail.com

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ABSTRACT

A protocol for the prevention of COVID-19 was established to maintain the continuity of the external dosimetry service, which is applied to both laboratory personnel and customers. The evolution of the dosimetry service at the national level between 2019 and 2020 was compared in terms of the number of institutions attended and the number of users, as well as a possible increase in the personal dose equivalent. The COVID-19 pandemic generated a decrease in the number of institutions served in the last quarters evaluated, but not in the number of dosimeters read by the service. There was an increase of 1, 1 times in the average personal equivalent dose in 2020 concerning 2019, without exceeding the dose restrictions. There was no absence of LAF-RAM technical personnel, therefore, the dosimetry service was maintained without interruptions, considering the adopted protocol to be adequate.

1. INTRODUCTION

Ionizing radiation is a type of energy that ionizes matter and has different applications in industry and medicine, among others. In the field of medicine, it is used for both therapeutic and diagnostic purposes; using X-ray generating equipment and equipment with radioactive sources.

The workflow around these fields of medicine and the personnel involved are known as occupationally exposed workers (OEW) that is, one who by the nature of his work is exposed to ionizing radiation.

As part of the health surveillance of the OEW according to the International Atomic Energy Agency (IAEA, 2014) "employers are responsible for making the necessary arrangements to assess and record occupational exposures and to monitor the health of workers." Part of these provisions is to ensure the assessment of occupational exposure through individual monitoring of radiation dose estimation received by each OEW, IAEA (2014).

At the national level, the entity responsible for guaranteeing and regulating ionizing radiation is the National Atomic Energy Commission (NAEC) designed from the Ionizing Radiation Law Ley 15 (1993). NAEC operates through the Directorate-General for Health Regulation (DGHR); on this basis, in 2011 the Technical Regulation for Protection against Ionizing Radiation (TRPAIR) was published, which establishes that authorization holders must be responsible for, among other requirements, the protection of workers against occupational exposure (National Atomic Energy Commission [NAEC], 2011).

The dose limits for occupational exposure of workers are described in the TRPAIR in different categories and considered a OEW from the age of 18 which should not exceed an effective dose of 20 mSv per year on average over a period of five consecutive years and also do not exceed an effective dose of 50 mSv in any year (NAEC 2011). These dose limits are aimed at whole-body dosimetry which is the topic of interest in this study.

Regarding dose restrictions, section II of the guide for the implementation of the technical regulation for protection against ionizing radiation in the practice of conventional and interventional radiology establishes that 10 mSv per year is applied for OEW with working days of 8 hours per day in 5 days per week considering 50 weeks per year (NAEC 2011).

Individual monitoring or monitoring of OEW can be performed through external dosimetry using specific devices known as dosimeters. At the national level, only the Laboratory of Radiation Physics and Metrology (LAF-RAM), with 27 years of experience in radiation protection, provides the service to all institutions that request it, thus contributing to compliance with the regulations.

Background of the external dosimeter service

The first efforts were made in 1990 to carry out individual monitoring in some hospitals in Managua, when a group of students of the Physics career was formed under the direction of Dr. Fabio Morales and the German professor Dr. Jörn Bleck Neuhaus (N. Road, F. Somarriba, F. López, personal communication, October 26, 2019). However, by March 1993 the National Autonomous University of Nicaragua, Managua (UNAN-MANAGUA) created the Laboratory of Radiation Physics and Metrology (LAF-RAM) for research purposes and service to society in the field of ionizing radiation, (N. Roas, F. Somarriba, F. López, personal communication, October 26, 2019).

The current technology used for individual monitoring is thermoluminescent and began in 1995, through cooperation with the International Atomic Energy Agency (IAEA) providing equipment such as detectors and thermoluminescent TLD readers (for its acronym in English) and training to laboratory personnel. (N. A. Roas Zúniga, F.I. Somarriba, F. López, personal communication, October 26, 2019).

News of the external dosimetry service

In general, the LAF-RAM through the service of the External Dosimetry Laboratory (LDE) registers TOE in different practices such as industry, diagnostic and therapeutic medicine, research, and regulation (LAF-RAM, 2020).

Radiological surveillance of TOEs through personal dosimetry is carried out with periods of dosimeter change mainly on a bimonthly basis, however, there are institutions with periods of monthly change according to their type of practice, and magnitude to monitor or policies of the institution itself or by mandate according to regulation.

By January 2019, the Laboratory had registered by agreement and contract the service of external personal dosimetry in the magnitude Hp(10), that is, monitoring with whole-body dosimeters, personal limb dosimetry in the magnitude Hp(0.07) (monitoring with ring dosimeters), environmental dosimetry H*(10), to 122 institutions with 1777 users within which 85 are private institutions and 37 public institutions. However, about 32 institutions were absent from service between six months to one year, the service considers them inactive for periods longer than two years.

In January 2020, 133 institutions with 1993 users or dosimeters were registered between agreements and contracts for the magnitudes Hp(10), H(10), and Hp(0.07), within which 99 are private institutions and 34 public institutions.

It is considered that the characteristics of the external dosimetry service are very dynamic for various reasons, as example, we have the reactivation of the service with those absent institutions, new institutions (some do not finish the new application procedures), requests for the constant registrations and cancellations of TOE inactive institutions. On the other hand, it is also observed in the first months of each year reactivations of services and new requests usually coincide with the annual inspection visits scheduled by the DGRS.

Performance during COVID-19

The disruption caused by the COVID-19 pandemic generated such uncertainty that the LDE service had to take measures to ensure its continuity and at the same time not be affected in terms of staff health. The importance of radiological surveillance of OEW was considered at all times, mainly those related to the medical area.

The immediate actions were the basic sanitary measures and protocols such as distancing, hand washing, and the use of masks disseminated by the World Health Organization (WHO, n.d.). Similarly, it was key to conduct research and participate in sharing experiences among laboratories in the region to implement best practices.

The measures were strengthened following the participation of the LDE team in the webinar: "COVID-19-Related Issues: A Medical Physics Perspective from Italy"; whose panelist was the director Antonella del Vecchio of the department of medical physics of the San Rafael hospital in Milan, Italy where she explained that the personal dosimetry is carried internally in the hospital and that they followed the protocol of the service to manipulate the dosimeters according to a scheme of permanence of the virus on different surfaces when compared with the materials that constitute the dosimeters. For example, copper, paper, and stainless steel have a time of permanence or abatement of the virus of 4, 24, and 48 hours respectively; however, plastic was presented with the longest dwell time around 72 hours, which is the largest component of dosimeters. This data allowed them to adopt waiting measures for their technical staff to perform the readings of the dosimeters in this case a week. (Old, 2020)(Old, 2020)

Valuing what was shown by the Italian experience and considering that the equipment and dosimeters of the dosimetry service of the San Rafael hospital in Milan are similar to those of the LDE Service, the readings of the dosimeters began to be carried out waiting 3 calendar days. On the other hand, all LAF-RAM staff participated in a second webinar held in May 2020 "Continuity in COVID-19 pandemic: How to run effective technical services for individual monitoring during a pandemic" by Burcin et al.(2020). As a result of the experiences shown in this seminar, a general protocol of the LAF-RAM prevention against COVID-19 was proposed in writing to give continuity to the services. This protocol was initially born as part of the LDE External Dosimetry Laboratory, however, it was extended to the other laboratories of the LAF-RAM.

Relationship between imaging rooms, COVID-19, and external personal dosimetry

At the same time, during the pandemic, it was recognized worldwide that one of the means of confirmation of the Covid-19 disease is studies using chest x-rays or chest scans with computed tomography on suspected patients or with symptoms (World Health Organization [WHO], 2020). This reaffirmed the commitment to continue the LDE service, but from another perspective, the question arose about the incidence of OEW doses in the face of a possible increase in chest examinations and comparing them with annual dose limits and restrictions.

In this sense, according to the National Security Council (CSN, 1990) (a competent body in the field of nuclear safety and radiation protection in Spain); radiation protection in a diagnostic X-ray room must guarantee the equivalent doses as low as reasonably possible to the TOE, patients and members of the public. This must be applied on three levels: from the point of view of the design and proper functioning of the X-ray generating equipment, verifying the design of shielding and distribution of the rooms in addition to signage, and a third level, during exposure situations, ensuring the use of personal protection and good practice.

In general, shielding calculations are made considering the worst scenario with conservative workloads, that is, maximum volumes of studies per room; defined as a function of the current of the X-ray tube and the time of radiation emission in a time interval usually one week (CSN, 1990). Under these criteria of calculation of armor, a safety factor is to be expected, making future forecasts such as an increase in workload, for example, the possible increase in chest x-rays for the diagnosis of COVID-19.

This study compares the performance and adaptation of the external dosimetry laboratory during the critical months of the pandemic concerning the months evaluated in 2019 based on a COVID-19 prevention protocol.

2. METHODOLOGY

COVID-19 Prevention Protocol

Meetings were held among the members of the External Dosimetry service including the customer service staff, the main difficulties were raised and possible general prevention strategies applied to the dosimetry service and laboratory were discussed. These ideas and strategies were described in a document that in turn was extended to all the services provided by the LAF-RAM, such as the Dosimetric Calibration Laboratory, the Internal Dosimetry Laboratory, and the Quality Control and Monitoring Laboratory (LAF-RAM, 2020).

In general, preventive customer service measures were started, where the use of a mask and the application of alcohol at the entrance of the LAF-RAM are requested for both visitors and all staff. For customer service, a chair was placed one meter away from the desk of the staff who attend. As for the dosimetry service, the received dosimeters were placed on tables covered with plastics or reused papers for sterilization and subsequent storage. All staff was guided to wash their hands after handling dosimeters and folders with the records of each institution.

Comparison of the service between 2019 and 2020

The evolution of the dosimetry service at the national level between 2019 and 2020 was compared, for this the data of the number of dosimeters read between each of the four quarters were used, the number of dosimeters reads is equivalent to the amount of OEW attended.

On the other hand, the number of institutions that made changes between these two years was also compared per year. Some variables were taken into consideration since some institutions had been absent for at least two years, others requested in 2020 for the first time the service, and others made the change of dosimeter extending the period starting in 2019 and returning in 2020.

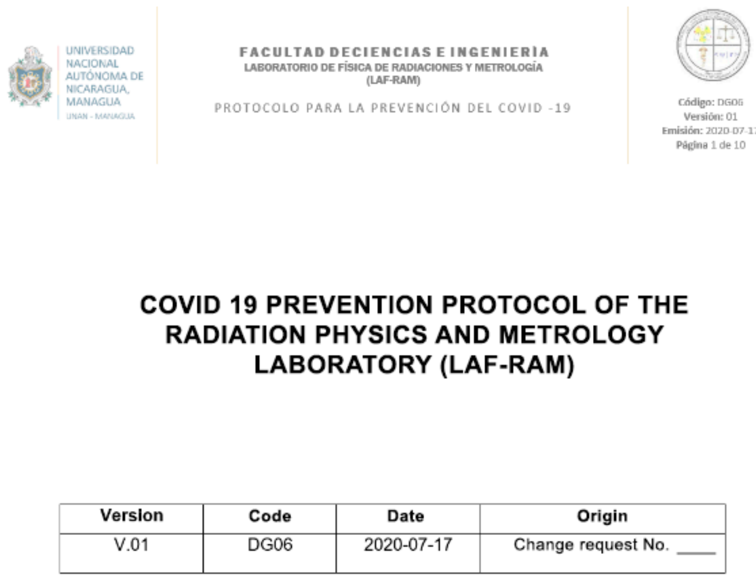
In the face of a possible doubt about the incidence of radiation doses of OEW due to increased workload, the personal equivalent dose Hp (10) of all diagnostic hospital institutions was compared. First, the average of Hp (10) per year of all health services in the area of diagnostics was obtained to compare it between 2019 and 2020. An ANOVA analysis was then performed comparing the average doses of these institutions, but by quarters between each year.

Using the ANOVA criterion, it was considered as a null hypothesis that there is no significant difference between the doses averages between the years 2019 and 2020; therefore, if the results indicate $p \leq \alpha$ the null hypothesis is rejected with p the probability of evidence against the null hypothesis and α the level of significance (Rubio et al., 2012).

3. RESULTS

Protocol

The Covid-19 Prevention Protocol adopted by all LAF-RAM staff was developed. The protocol consists of ten pages and is part of the QUALITY Management System of the LAF-RAM. Figure 1 shows the cover page of the document, and like any document in the management system is under revision to update it.



UNIVERSIDAD NACIONAL AUTÓNOMA DE NICARAGUA, MANAGUA
UNAN - MANAGUA

FACULTAD DECIENCIAS E INGENIERÍA
LABORATORIO DE FÍSICA DE RADIACIONES Y METROLOGÍA (LAF-RAM)
PROTOCOLO PARA LA PREVENCIÓN DEL COVID -19

Código: DG06
Versión: 01
Emisión: 2020-07-17
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COVID 19 PREVENTION PROTOCOL OF THE RADIATION PHYSICS AND METROLOGY LABORATORY (LAF-RAM)

Version	Code	Date	Origin
V.01	DG06	2020-07-17	Change request No. ____

Figure 1.

Cover of the COVID-19 prevention protocol

LDE Service 2019 and 2020

As mentioned above the dosimetry service is very dynamic, generally, an increase in requests is expected in the first months of each year, which is consistent with the results shown in Figure 2. In the comparison of the II, III, and IV quarters, there was less presence of institutions in 2020 compared to 2019, even with the first quarter of the same year, it was considered that this decrease is attributable to the impact of COVID-19. In the last quarter of 2020, only 60% of institutions changed dosimeters.

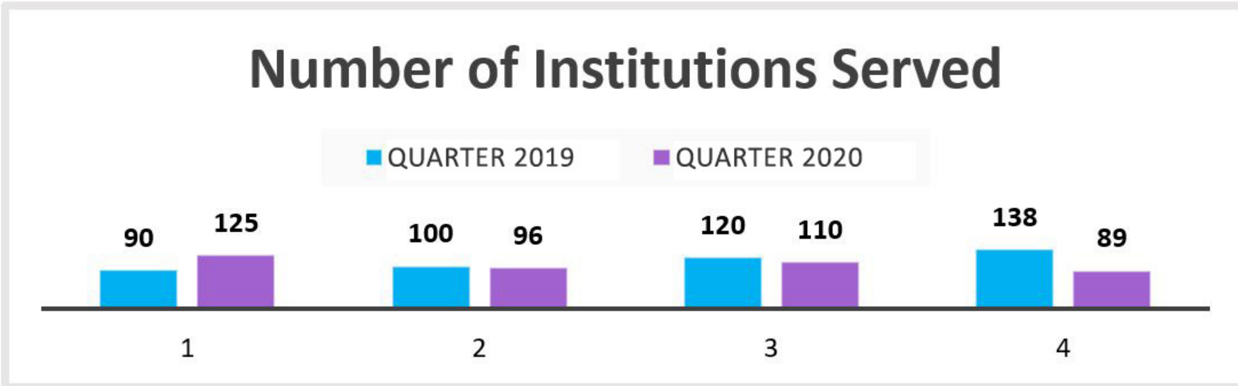

Figure 2.

Comparison by a quarter of the number of institutions served

Comparing the quarters of 2019 with 2020 in terms of the number of dosimeters read equivalent to the amount of TOE, increases were observed in each quarter of 2020 for the corresponding ones of the previous year, except in the last quarter (see Figure 3).

This graph indicates that in the first quarter when there was an increase in institutions there was also a considerable increase in dosimeters requested to be evaluated. However, in the course of 2020, it was observed that the number of dosimeters decreased compared to the first quarter this result is probably because the institutions extended their change periods from two to 6 months, others were absent for the rest of the year and finally, it was observed that most of the institutions notified users and therefore dosimeters as low.

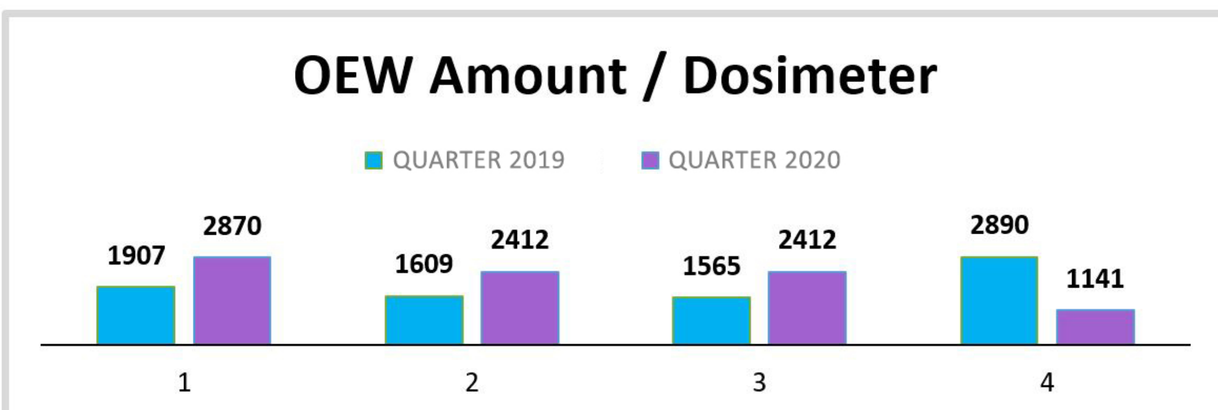

Figure 3.

Comparison per quarter of the amount of dosimeter reading per TOE

The above results are based on the log records of the work procedures of the LDE service such as the Dosimeter reading log, Dosimeter zeroing log, and Dosimeter delivery log.

Regarding the doses of OEW, the personal equivalent dose Hp (10) annual cumulative average shown in Figure 4 was compared. In this analysis, only the dosimetric information was included in the hospital institutions of the diagnostic area. In this sense, for each institution, the accumulated annual dose was calculated and the average was obtained for each year; the results indicate that the cumulative dose is 1.1 times higher in 2020 compared to 2019.

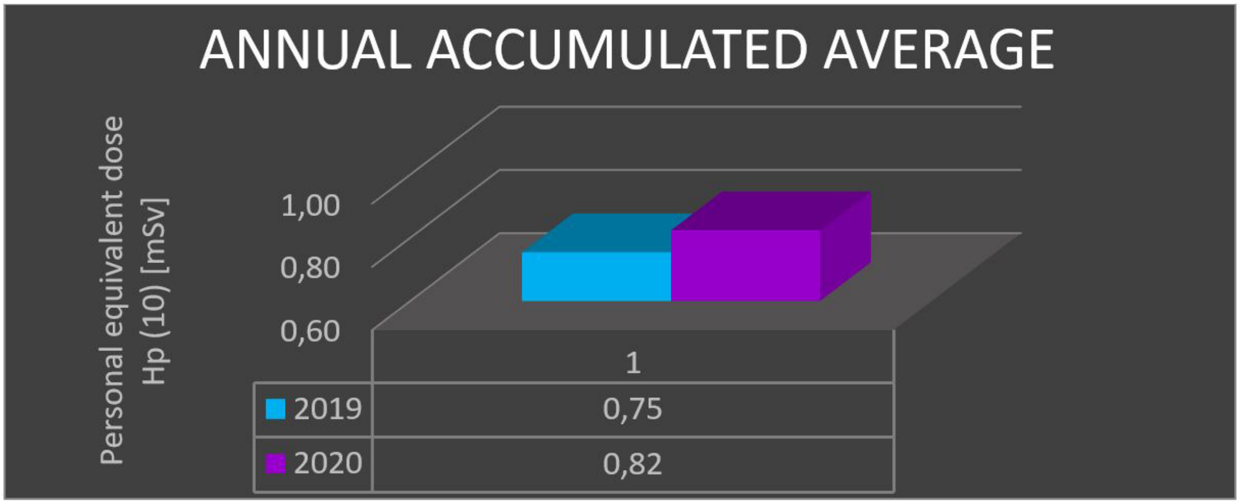

Figure 4.

Cumulative average of personal equivalent dose Hp(10) per year.

On the other hand, it was considered appropriate to compare the hp dose (10) in any of the quarters of 2020 to 2019. The results are shown in Figure 5 where the first three-quarters of Hp (10) are similar, however, in the fourth quarter of 2020, a higher value of Hp (10) is observed this value is 3 times higher compared to the result of Hp (10) in the previous year.

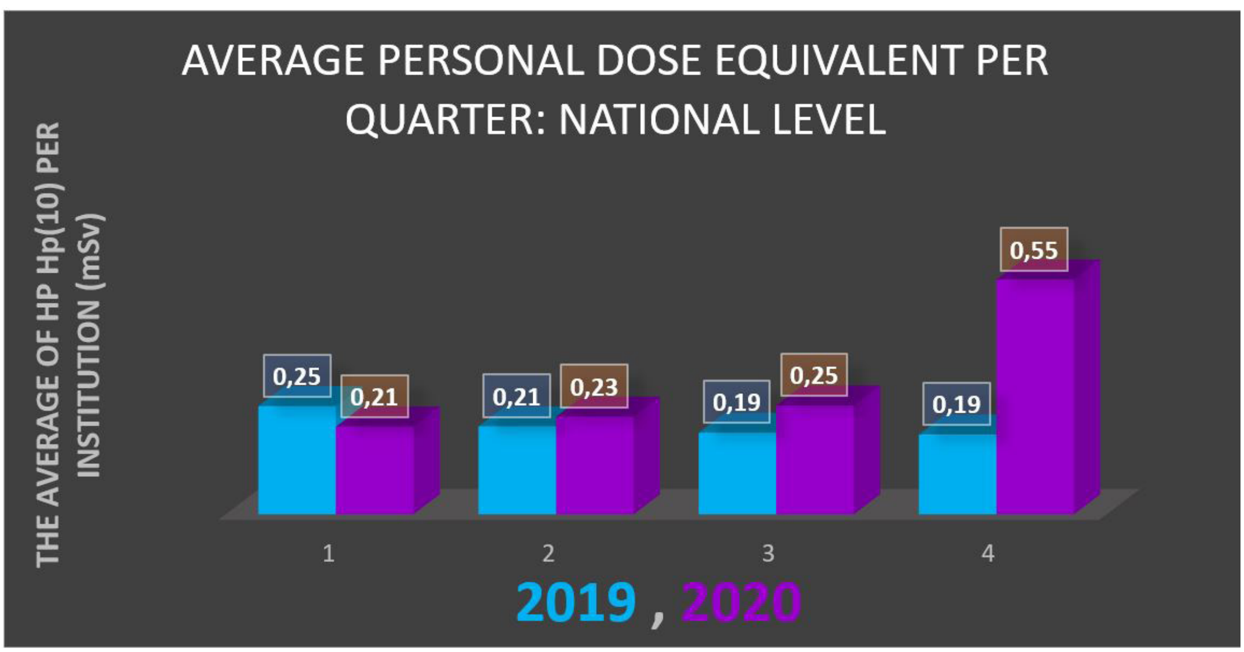

Figure 5.

Comparison of personal equivalent dose Hp(10) in the diagnostic area by trimesters.

The analysis of ANOVA indicated in Table 1 shows that the F Snedecor statistic is equivalent to 6.290 and the p-value of 0.000 i.e. $p \leq \alpha$. With this result, the null hypothesis is rejected, that is, the averages between the doses of each trimester are different. The results in detail are shown in Table 1.

Table 1.

ANOVA analysis results of the average doses per year.

	Sum of squares	Degrees of freedom	Quadratic mean	F	Itself.
Intra groups	4.168	7	.595	6.290	.000
Inter groups	50.546	534	.095		
Total	54.714	541			

It is necessary in this case to determine between which quarters there is a significant difference in the means of the doses for this the analysis of contrasts a posteriori was carried out using the Tukey statistic to check if the values of average doses vary between quarters of each year. Table 2 was constructed by making multiple comparisons with the dose-dependent variable. The results show that there is a significant difference only when comparing the average doses of the fourth quarter of 2020 with the rest of the quarters distributed between the years 2019 and 2020.

Table 2.

Results of Multiple Comparisons using Tukey statistics, between quarters

(I) QUARTER	(J) QUARTER	Mean Differences (I-J)	Typical error	Itself.	95% confidence interval	
					Lower limit	Upper limit
QUARTER I 2019	TRIMESTREII 2019	.04936	.05116	.979	-.1063	.2050
	TRIMESTREIII 2019	.06346	.05257	.930	-.0965	.2234
	TRIMESTREIV 2019	.06813	.05936	.946	-.1125	.2487
	TRIMESTREI 2020	.04898	.04750	.970	-.0956	.1935
	TRIMESTREII 2020	.02126	.05257	1.000	-.1387	.1812
	TRIMESTREIII 2020	-.00418	.05257	1.000	-.1642	.1558
	TRIMESTER 2020	-.27932*	.06021	.000	-.4625	-.0961
QUARTER II 2019	TRIMESTREI 2019	-.04936	.05116	.979	-.2050	.1063
	TRIMESTREIII 2019	.01410	.05136	1.000	-.1422	.1704
	TRIMESTREIV 2019	.01877	.05828	1.000	-.1586	.1961
	TRIMESTER 2020	-.00038	.04615	1.000	-.1408	.1401
	TRIMESTREII 2020	-.02810	.05136	.999	-.1844	.1282
	TRIMESTREIII 2020	-.05354	.05136	.968	-.2098	.1027
	TRIMESTER 2020	-.32868*	.05915	.000	-.5087	-.1487

(I) QUARTER	(J) QUARTER	Mean Differences (I-J)	Typical error	Itself.	95% confidence interval	
					Lower limit	Upper limit
QUARTER III 2019	TRIMESTREI 2019	-.06346	.05257	.930	-.2234	.0965
	TRIMESTREII 2019	-.01410	.05136	1.000	-.1704	.1422
	TRIMESTREIV 2019	.00467	.05953	1.000	-.1765	.1858
	TRIMESTER 2020	-.01448	.04771	1.000	-.1597	.1307
	TRIMESTREII 2020	-.04221	.05276	.993	-.2028	.1184
	TRIMESTREIII 2020	-.06765	.05276	.905	-.2282	.0929
	TRIMESTREIV 2020	-.34278*	.06038	.000	-.5265	-.1590
QUARTER IV 2019	TRIMESTREI 2019	-.06813	.05936	.946	-.2487	.1125
	TRIMESTREII 2019	-.01877	.05828	1.000	-.1961	.1586
	TRIMESTREIII 2019	-.00467	.05953	1.000	-.1858	.1765
	TRIMESTER 2020	-.01915	.05510	1.000	-.1868	.1485
	TRIMESTREII 2020	-.04687	.05953	.994	-.2280	.1343
	TRIMESTREIII 2020	-.07231	.05953	.927	-.2534	.1088
	TRIMESTREIV 2020	-.34745*	.06637	.000	-.5494	-.1455
QUARTER AND 2020	TRIMESTREI 2019	-.04898	.04750	.970	-.1935	.0956
	TRIMESTREII 2019	.00038	.04615	1.000	-.1401	.1408
	TRIMESTREIII 2019	.01448	.04771	1.000	-.1307	.1597
	TRIMESTREIV 2019	.01915	.05510	1.000	-.1485	.1868
	TRIMESTREII 2020	-.02772	.04771	.999	-.1729	.1175
	TRIMESTREIII 2020	-.05316	.04771	.954	-.1984	.0920
	TRIMESTREIV 2020	-.32830*	.05602	.000	-.4988	-.1578

(I) QUARTER	(J) QUARTER	Mean Differences (I-J)	Typical error	Itself.	95% confidence interval	
					Lower limit	Upper limit
QUARTER II 2020	TRIMESTREI 2019	-.02126	.05257	1.000	-.1812	.1387
	TRIMESTREII 2019	.02810	.05136	.999	-.1282	.1844
	TRIMESTREIII 2019	.04221	.05276	.993	-.1184	.2028
	TRIMESTREIV 2019	.04687	.05953	.994	-.1343	.2280
	TRIMESTREI 2020	.02772	.04771	.999	-.1175	.1729
	TRIMESTREIII 2020	-.02544	.05276	1.000	-.1860	.1351
	TRIMESTER 2020	-.30057*	.06038	.000	-.4843	-.1168
QUARTER III 2020	TRIMESTREI 2019	.00418	.05257	1.000	-.1558	.1642
	TRIMESTREII 2019	.05354	.05136	.968	-.1027	.2098
	TRIMESTREIII 2019	.06765	.05276	.905	-.0929	.2282
	TRIMESTREIV 2019	.07231	.05953	.927	-.1088	.2534
	TRIMESTREI 2020	.05316	.04771	.954	-.0920	.1984
	TRIMESTREII 2020	.02544	.05276	1.000	-.1351	.1860
	TRIMESTREIV 2020	-.27513*	.06038	.000	-.4589	-.0914
QUARTER IV 2020	TRIMESTREI 2019	.27932*	.06021	.000	.0961	.4625
	TRIMESTREII 2019	.32868*	.05915	.000	.1487	.5087
	TRIMESTREIII 2019	.34278*	.06038	.000	.1590	.5265
	TRIMESTREIV 2019	.34745*	.06637	.000	.1455	.5494
	TRIMESTREI 2020	.32830*	.05602	.000	.1578	.4988
	TRIMESTREII 2020	.30057*	.06038	.000	.1168	.4843
	TRIMESTREIII 2020	.27513*	.06038	.000	.0914	.4589

*. The mean difference is significant at level 0.05.

4. DISCUSSION

In general, for everything that corresponds to the external dosimetry service, at least 5 institutions were found whose change period exceeded six months. Other institutions suspended their services, for example, nuclear medicine therapy due to the lack of entry into the country of radioactive material input.

In the first quarter of 2020, there was an increase in OEW and institutions compared to 2019. The amount of OEW second and third quarters of 2020 remained but decreased compared to the first quarter. However, in all cases, they are exceeded by a factor of 1.5 compared to 2019. According to the institutions served in the second and third quarters of 2020, a smaller amount was found compared to the corresponding ones of 2019, which is not significant.

The amount of OEW increased considerably in the first quarter with a decrease as expected by the health crisis, when it was reported in most institutions staff on leave, for various reasons, some reported as temporary leave or permanent discharge, however, the readings of these dosimeters must be made to make the dosimetric report.

Regarding the average doses of the diagnostic medical area, an increase in the annual average is observed in 2020 due to an increase in the average dose of the last quarter of this year. This is attributable to the presence of atypical doses in the diagnostic area such as 6.61 mSv observed in a private clinic.

5. CONCLUSIONS

There was no loss of technical staff of the LAF-RAM, therefore, the dosimetry service was maintained without interruptions, considering the adopted protocol adequate.

The COVID-19 pandemic generated a decrease in the number of institutions served in the last quarters evaluated, but not the amount of reading of the dosimeters read by the service.

Although there is an increase in the personal equivalent doses of Hp (10) in the year 2020 compared to 2019, the dose restrictions are not exceeded in any year therefore it is considered that at least the rooms are designed with protection barriers that meet the requirements this with the assumption that an increase in the workload was suffered and the staff follows the work protocols considered as good practices.

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