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Impact of COVID-19 on Nuclear Medicine Departments in Africa and Latin America

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The International Atomic Energy Agency (IAEA) conducted a survey to determine the impact of the COVID-19 pandemic on nuclear medicine services worldwide at two specific time-points: June and October 2020. In this paper, we describe the impact of COVID-19 on nuclear medicine departments in Africa (19 countries, 41 centers) and Latin America (15 countries, 83 centers) obtained from the survey. Respectively in Africa and Latin America, the volume of nuclear medicine procedures decreased by 69% and 79% in June 2020 and 44% and 67% in October 2020. Among the nuclear medicine procedures, oncological PET studies showed less of a decline in utilization compared to conventional nuclear medicine studies. A gradual trend towards a return to the pre-COVID-19 status of the supply chains of radioisotopes, generators, and other essential materials was evident. Overall, in 2020, the pandemic-related challenges resulted in significant decrease in nuclear medicine diagnostic and therapeutic procedures in Africa and Latin America. The impact was more pronounced in Latin America than in Africa. The current COVID-19 pandemic poses many challenges for the practice of nuclear medicine. If adequately prepared, departments can continue to deliver their essential services, while mitigating the risk for patients and staff. This requires adapting the SOPs, as quickly as possible, to meet the new requirements. Semin Nucl Med 52:31-40 © 2021 Elsevier Inc. All rights reserved.

Introduction

Coronaviruses are common viruses. Based on their characteristics they can be defined as nonsegmented, enveloped, positive-sense, single-strand ribonucleic acid viruses,

categorized as the Coronaviridae family. Until 2019, six main types of coronavirus had been identified as human pathogens: two thirds of them (four of the six types) caused mild respiratory symptoms, while the remaining two types caused the Middle East respiratory syndrome (MERS), known as MERS coronavirus, and severe acute respiratory syndrome (SARS), known as SARS coronavirus, both types having been responsible for epidemics with high mortality rates.

At the end of 2019, a new type of coronavirus was identified in biological samples, mainly from the lower respiratory tract of several patients presenting a new and unknown disease in Wuhan, China. In this new disease, later called COVID-19 or novel COVID-19–infected pneumonia (NCIP), patients presented with symptoms of severe pneumonia, including fever, fatigue, dry cough, and respiratory distress. The World Health Organization announced the outbreak of a pandemic in March 2020. Since then, the world has suffered several waves of the pandemic. The present situation (April 2021) is one of transition, as some countries display diverse recovery phases while others are enduring more peaks in infection rates, with regional variations noted even

Abbreviations and acronyms: COVID-19, Coronavirus Disease 2019; CNM, Conventional Nuclear Medicine; HIC, High-Income Countries; IAEA, International Atomic Energy Agency; IPC, Infection Prevention and Control; IRIS, International Research Integration System; LIC, Low-Income Countries; LMIC, Lower-Middle-Income Countries; PET, Positron Emission Tomography; PPE, Personal Protective Equipment; UMIC, Upper-Middle-Income Countries; WHO, World Health Organisation

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within the same country. The WHO dashboard shows that global cases have exceeded 146 million and deaths have crossed 3.1 million.¹ Several countries have initiated targeted vaccination efforts while new COVID variants have been identified.¹⁻⁴

This worldwide health, social and economic crisis has spotlighted great global variability in the preparedness and response of healthcare systems. To address the impact of the COVID-19 crisis on essential health services, the WHO published “COVID-19: Operational Guidance for maintaining essential health services during an outbreak”⁵ and the International Atomic Energy Agency (IAEA) produced technical guidance to help nuclear medicine departments continue to provide essential healthcare services. The IAEA also supplied health professionals worldwide with informational and supportive resources, including webinars and open-access publications.⁶⁻⁹

In this paper, we describe results from a global web-based survey, conducted by the IAEA and designed to assess the impact of the pandemic on nuclear medicine services worldwide at two specific time-points: June and October 2020. Data extracted from the global survey in this paper focuses on the situational status of nuclear medicine services in Africa and Latin America.

The selection of time points for analysis was based on the stage of the pandemic. Despite some differences in the timing of the COVID-19 waves between regions, most countries were in a post-peak phase at the beginning of the summer (June), whereas in autumn (October) most were suffering the second wave of the pandemic¹.

IAEA Survey in Africa and Latin America

As a follow-up of the first IAEA survey spanning April–May 2020 and published in the *Journal of Nuclear Medicine* in September 2020,¹⁰ an invitation to participate in a web-based questionnaire was extended to nuclear medicine facilities worldwide. Survey entries were collected using a secure software platform hosted by the IAEA, the International Research Integration System (IRIS, <https://iris.iaea.org>). Invitations to participate in the survey were distributed by the IAEA and through personal and social media networks. The survey was made available for 6 weeks, from November 23 to December 31, 2020.

Questionnaires covered the following categories: operational aspects of nuclear medicine facilities, impact on diagnostic and therapeutic nuclear medicine procedures, availability of personal protective equipment (PPE), and supply of radiotracers and other essential materials.

All entries were reviewed and checked for missing data, implausible-appearing data, and duplicate or inconsistent entries from the same institution. Data was compiled in Excel for Microsoft 365 (Microsoft, Redmond, Washington). Maps were created using Mapbox. Responses to open-ended questions were collected separately.

Where applicable, we report mean and median results (as well as ranges where necessary). Results presented herein are aligned with the aforementioned categories.

A total of 505 responses were received from 96 countries for the global survey. For this present paper, data was extracted from 124 questionnaires coming from Africa and Latin America (Table 1).

Globally, the comparison with the average number of nuclear medicine procedures performed before the COVID-19 pandemic (diagnostic and therapeutic) showed a dramatic decrease; in Africa, the volume decreased by 69% in June 2020 and 44% in October 2020. In 20% of reported cases in June and in 7% of cases in October 2020, nuclear medicine activity stopped completely. In Latin America, the volume decreased by 79% in June 2020 and 67% in October 2020; in 20% of reported cases in June and in 10% of cases in October 2020, nuclear medicine activity ceased completely.

Table 1 Geographical Distribution of the Responders

IAEA Region Name	Country Name	Number of records
Africa	Algeria	3
	Egypt	2
	Ethiopia	1
	Ghana	1
	Kenya	2
	Libya	1
	Mauritania	3
	Mauritius	2
	Morocco	1
	Niger	1
	Nigeria	2
	Senegal	1
	South Africa	15
	Tanzania	1
	Togo	1
	Tunisia	1
	Uganda	1
	Zambia	1
	Zimbabwe	1
	Total Africa	19
Latin America	Argentina	12
	Brazil	13
	Chile	5
	Colombia	6
	Costa Rica	2
	Cuba	1
	Dominican Republic	1
	Ecuador	4
	El Salvador	1
	Mexico	27
	Nicaragua	3
	Paraguay	2
	Peru	3
	Puerto Rico (US)	1
Uruguay	2	
Total Latin America	15	83
Grand Total	34	124

Conventional Nuclear Medicine Procedures

Of the responding centers, 103 performed conventional nuclear medicine diagnostic procedures of which 32 were in Africa and 71 in Latin America. Compared to a pre-COVID-19 baseline, the utilization of conventional nuclear medicine diagnostic procedures decreased by 77% and 64% in June and October 2020, respectively.

Situation in Africa

The reductions affected conventional nuclear medicine by 71% and 44%, with complete standstill of activities in 19% and 6% of cases, in June and October 2020, respectively. However, the activity was higher than the baseline in 4% and 22% of cases, in June and October 2020, respectively.

In June 2020, all studies appeared to be affected equally, with a reduction range between 73% (bone scans) and 65% (thyroid scans), while in October 2020 bone and thyroid scans were less affected by the COVID-19 pandemic (Table 2).

Situation in Latin America

The reductions affected conventional nuclear medicine by 79% and 72%, with a complete halt of activity in 19% and

9% of cases, in June and October 2020, respectively. However, the activity was higher than the baseline in 10% of cases, in both June and October 2020.

In June 2020, all studies appeared to be affected equally, with a reduction range between 85% (myocardial perfusion scans) and 73% (lung scans), while in October 2020, lung scans and sentinel lymph node procedures were less affected by the COVID-19 pandemic (Table 3).

PET/CT Procedures

Of the responding centers, 52 perform PET procedures of which 16 are in Africa and 36 in Latin America. Compared to a pre-COVID-19 baseline, the utilization of PET procedures decreased by 79% and 47% in June and October 2020, respectively.

Situation in Africa

The reductions affected PET procedures by 58% and 45%, in June and October 2020, respectively, with complete stop of activity in 3% of cases in October 2020. However, the activity was higher than the baseline in 5% and 18% of cases, in June and October 2020, respectively. The decrease affected in a

Table 2 Average Variation in Conventional Nuclear Medicine Diagnostic Procedures Per Exams - Africa

Exam	Numbers	Decrease (complete)	Unchanged	Increase
Bone scan				
June%	26	73 (11)	19	8
October%	26	38 (4)	35	27
Myocardial perfusion imaging				
June%	23	70 (26)	30	0
October%	23	52 (13)	22	26
Lung scans				
June%	21	67 (14)	24	9
October%	21	48 (5)	28	24
Renal scans				
June%	26	73 (15)	23	4
October%	26	42 (0)	35	23
Thyroid studies				
June%	26	65 (15)	31	4
October%	26	35 (0)	46	19
Sentinel node detection				
June%	19	68 (21)	26	5
October%	19	53 (10)	37	10
Parathyroid scan				
June%	26	73 (23)	23	4
October%	26	35 (8)	42	23
Brain studies				
June%	10	70 (30)	30	0
October%	10	60 (20)	30	10
Other studies				
June%	20	70 (20)	25	5
October%	20	45 (5)	30	25
Total Conventional Nuclear Medicine Studies				
June%	197	71 (19)	25	4
October%	197	44 (6)	34	22

Table 3 Average Variation in Conventional Nuclear Medicine Diagnostic Procedures Per Exams - Latin America

Exam	Total number of procedures	Decrease %		Unchanged %	Increase %
		total	(complete)		
Bone scan					
June%	69	81	13	9	10
October%	68	70	7	12	18
Myocardial perfusion imaging					
June%	61	85	16	5	10
October%	62	79	8	8	13
Lung scans					
June%	60	73	25	20	7
October%	60	70	15	23	7
Renal scans					
June%	68	82	15	9	9
October%	68	78	7	12	10
Thyroid studies					
June%	66	82	18	9	9
October%	66	73	8	12	10
Sentinel node detection					
June%	53	81	21	15	4
October%	54	65	11	31	4
Parathyroid scan					
June%	62	77	23	15	8
October%	63	65	11	31	4
Brain studies					
June%	40	77	23	15	8
October%	40	63	18	28	10
Other studies					
June%	52	77	17	15	8
October%	53	74	6	17	9
Total Conventional Nuclear Medicine Studies					
June%	423	80	19	12	8
October%	534	72	9	18	11

similar way oncologic and non-oncologic PET procedures, both in June and October 2020 (Table 4).

The decrease equally affected oncologic and nononcologic PET procedures in June 2020, while in October 2020 non-oncologic PET procedures were the most affected (Table 5).

Situation in Latin America

The reductions affected PET procedures by 89% and 48%, with complete stop of activity in 15% and 6% of cases, in June and October 2020, respectively. However, the activity was higher than the baseline in 2% and 17% of cases, in June and October 2020, respectively.

Impact on Radionuclide Therapies

Of the responding centers, 90 perform radionuclide therapy of which 32 in Africa and 58 in Latin America. Compared to

Table 4 Average Variation in PET Procedures Per Exams – Africa

Exam	Numbers	Decrease (complete)	Unchanged	Increase
PET - non Oncology				
June%	10	60 (0)	40	0
October%	10	40 (10)	50	10
PET - Oncology				
June%	28	57 (0)	36	7
October%	28	46	32	22
Total PET Studies				
June%	38	58 (0)	37	5
October%	38	45 (3)	37	18

Table 5 Average Variation in Pet Procedures Per Exams – Latin America

Exam	Numbers	Decrease (complete)	Unchanged	Increase
PET - non Oncology				
June%	23	87 (22)	13	0
October%	23	57 (4)	30	13
PET - Oncology				
June%	60	90 (12)	7	3
October%	60	45 (7)	37	18
Total PET Studies				
June%	83	89 (15)	9	2
October%	83	48 (6)	35	17

a pre-COVID-19 baseline, the utilization of radionuclide therapies decreased by 71% and 53% in June and October 2020, respectively.

Situation in Africa

The reductions affected radionuclide therapies by 66% and 44%, with complete stop of activity in 28% and 10% of cases, in June and October 2020, respectively. However, the activity was higher than the baseline in 9% and 27% of cases, in June and October 2020, respectively.

In June 2020, the reduction was less evident in PRRT (44%) and PSMA therapy (46%), while in October 2020 thyroid cancer treatment was affected by only 28% (Table 6).

Situation in Latin America

The reductions affected radionuclide therapies by 75% and 58%, with complete stop of activity in 29% and 16% of cases, in June and October 2020, respectively. However, the activity was higher than the baseline in 7% and 12% of cases, in June and October 2020, respectively.

Table 6 Average Variation Per Radionuclide Therapies - Africa

Treatment	Numbers	Decrease (complete)	Unchanged	Increase
Thyroid cancer				
June%	25	68 (20)	24	8
October%	25	28 (0)	32	40
Thyroid benign				
June%	27	70 (22)	19	11
October%	27	44 (0)	26	30
PRRT				
June%	9	44 (11)	44	11
October%	9	33 (11)	44	22
PSMA				
June%	13	46 (31)	39	15
October%	13	46 (23)	39	15
Bone pain palliation				
June%	4	100 (75)	0	0
October%	4	100 (75)	0	0
Other treatments				
June%	10	80 (40)	20	0
October%	10	80 (40)	20	0
Total treatments				
June%	88	66 (28)	25	9
October%	88	44 (10)	28	27

The reduction was more evident in thyroid treatments, both in June 2020 and October 2020 (Table 7).

Personal Protective Equipment (PPE)

Forty percent of the 124 respondents reported a shortage of PPE in June 2020. This percentage dropped to 36% in October 2020. As for the availability of PPE, 32% of sites reported that stockpiles of PPE would last more than one month while fewer than two days for 7%. Respondents from the Latin American region were more impacted than respondents from the African region (Tables 8 and 9).

Employee Health and Organizational Changes

Fifty-eight percent of the 124 respondents experienced COVID-19 infections within their own departments. Thirty-

Table 7 Average Variation Per Radionuclide Therapies - Latin America

Treatment	Numbers	Decrease (complete)	Unchanged	Increase
Thyroid cancer				
June%	42	79 (12)	14	5
October%	43	63 (12)	21	16
Thyroid benign				
June%	45	80 (31)	11	9
October%	46	63 (15)	24	13
PRRT				
June%	10	70 (20)	30	0
October%	10	40 (10)	60	0
PSMA				
June%	12	67 (25)	33	0
October%	12	33 (17)	58	8
Bone pain palliation				
June%	13	62 (23)	31	8
October%	13	69 (23)	23	8
Other treatments				
June%	17	59 (29)	41	0
October%	17	47 (24)	35	18
Total treatments				
June%	136	75 (29)	18	7
October%	139	58 (16)	30	12

Table 8 Shortage of PPE in June and October 2020

		Africa		Latin America		Total	
		Centres	%	Centres	%	Centres	%
Total Procedures		41	100	83	100	124	100
June	yes	12	29	37	45	49	40
	no	25	65	43	52	68	54
	?	4	10	3	3	7	6
October	yes	11	27	34	45	45	36
	no	26	63	47	57	73	59
	?	4	10	2	2	6	5

two percent of the respondents experienced a relocation of their employees. Fifty-six percent of the respondents modified working hours. In approximately 65% of the cases, the employees were laid-off. Respondents from the Latin American region were more impacted than respondents from the African region (Table 10).

Demands and Supplies of Materials

Insufficient supplies of radioisotopes, generators, and kits were reported especially for ^{131}I and for $^{99\text{m}}\text{Tc}$ generators (Table 11)

Discussion

At the time of the survey, the Latin American and African regions were among the regions most significantly disrupted by the COVID-19 pandemic, which has led to enormous

challenges for their already overburdened healthcare systems, either during the preparation, response, or recovery phases of the pandemic. Most countries have had to reinstate varying degrees of lockdown and adaptive and continuous shifts in the functioning of healthcare resources to be able to attend to the exponentially increasing burden due to COVID-19. Many world regions have seen their healthcare systems stretched beyond their previously supposed limits by postponing non-urgent procedures or consultations and dedicating all available resources to COVID-19 patients. At the same time, attention to other diseases has been compromised to varying degrees, both for out- and inpatients. One example that has seriously affected healthcare is the need to implement strict measures to prevent and control infection transmission.¹¹⁻¹³ Moreover, the mid-term and long-term consequences of the enormous increases in demand suffered by healthcare systems and healthcare workers have yet to be assessed, but they threaten to leave some healthcare systems overstretched and without the capacity to operate effectively. Some of the countries presenting the highest COVID-19 death-rates are in these countries, as is the case of Mexico (world's highest case/fatality ratio) and Brazil (world's third

Table 9 PPE on Stock

	Africa		Latin America		Total	
	Centers	%	Centers	%	Centers	%
<2 days	4	9	5	6	9	7
2-28 days	17	38	50	60	67	54
> 28 days	14	31	25	30	39	32
?	6	13	3	4	9	7
Total	45	100	83	100	124	100

Table 10 Employee Health and Organizational Changes

		Africa		Latin America		Total	
		Centers	%	Centers	%	Centers	%
Total Procedures		41	100	83	100	124	100
Infection	Y	20	48	23	28	43	35
	N	17	42	55	66	72	58
	?	4	10	5	6	9	7
Relocation	Y	26	63	48	58	74	60
	N	10	24	30	36	40	32
	?	5	13	5	6	10	8
Working hours modified	Y	12	29	24	29	36	29
	N	17	42	53	64	70	56
	?	12	29	6	7	18	15
Layoff	Y	23	56	58	70	81	65
	N	6	15	19	23	25	20
	?	12	29	6	7	18	15

Table 11 Demand and Supplies of Materials

		Africa		Latin America		Total	
		Centers	%	Centers	%	Centers	%
Total Procedures		41	100	83	100	124	100
Demand Tc generators	Y	23	56	32	39	55	44
	N	13	32	30	36	43	35
	?	5	12	21	25	26	21
Supply Tc generators June	Y	11	27	40	48	51	41
	N	11	27	8	10	19	15
	?	19	46	35	42	54	44
Supply Tc generators October	Y	19	46	47	56	66	53
	N	2	5	4	5	6	5
	?	20	49	32	39	52	42
Supply SPECT kits June	Y	11	27	28	33	39	31
	N	10	24	3	4	13	11
	?	20	49	52	63	72	58
Supply SPECT kits October	Y	16	39	29	35	45	36
	N	3	7	2	2	5	4
	?	22	54	52	63	74	60
Supply PET RF June	Y	18	44	43	52	61	49
	N	8	19	5	6	13	11
	?	15	37	35	42	50	40
Supply PET RF October	Y	14	34	28	34	42	34
	N	21	51	5	6	26	21
	?	6	15	50	60	56	45
Supply therapy RF June	Y	14	34	52	63	66	53
	N	20	49	25	30	45	36
	?	7	17	6	7	13	11
Supply therapy RF October	Y	28	68	44	53	72	58
	N	11	27	12	14	23	19
	?	2	5	27	33	29	23

highest number of cumulative cases of COVID-19 and second highest death toll). In Africa, many countries have suffered severe practical difficulties to contain the virus or deal with its healthcare, economic and social consequences. In this region, healthcare systems have fought the pandemic by dramatically reducing outpatient and inpatient non-COVID-19 related procedures and putting in place measures to prevent and control the transmission of the infection.

A recent survey by the IAEA evaluated the impact of the pandemic on nuclear medicine departments and their services worldwide.¹⁰ It demonstrated that nuclear medicine procedures performed in April 2020 decreased globally, with variation depending on the type of procedures, with a 54% decrease in ^{99m}Tc studies, 36% decrease in PET exams, and 45% average decrease in radionuclide therapies. As mentioned earlier, one of the main reasons was the postponement of non-emergent procedures, while another main reason was the inevitable disruption, sometimes in several phases, of the medical supply chains. Both scenarios affected lower- middle-income countries (LMICs) comparatively more than HICs.

Due to the COVID-19 pandemic and implemented lockdown measures, known risk/benefit ratios have changed for nuclear medicine vs. the risks of both infection exposure (for patients and staff) and due to the postponement or cancellation of procedures.

This paper analyzed data from a new IAEA online survey (Giammarile, in press), specifically aimed at assessing nuclear medicine departments in Africa and Latin America. The aim of the survey was to measure the impact of COVID-19 on nuclear medicine departments at two time-points in 2020; June and October. The reason for choosing these time-points was that most countries coincided in being at similar phases of the pandemic. In June, most countries were experiencing a post-peak phase, while in October most were going through a new wave.

The limitation of this paper is that it is survey-based and, therefore, a great part of the data derives from the voluntary participation of professionals working in the field of nuclear medicine in participating countries. Even though the IAEA has quality control mechanisms in place to ensure the highest level of validation of data obtained from the survey, the information supplied by the voluntary collaborators as well as available information sources greatly influences the accuracy and consistency of the global estimates obtained.

The survey shows that the reduction in nuclear medicine procedures in June was greater than in October, and more pronounced than the diminution previously delineated by the April 2020 survey¹⁰ at the beginning of the pandemic. Even the October 2020 average procedural numbers remain far from a restoration to the prepandemic norms in countries.

A total of 124 centers (83 from Latin America and 41 from Africa) from 34 countries (15 from Latin America and 19 from Africa) responded to the questionnaire. The number of responses was very high in countries in which nuclear medicine has a wider integration in the healthcare system, such as Mexico (27 questionnaires), Brazil (13 questionnaires) or South Africa (15 questionnaires): countries that are in the

top of their income range of this group of countries. This finding is similar, with the expected limitations, to our previous survey where the responses from higher-income countries were preponderant.¹⁰

Overall, the number of nuclear medicine procedures (diagnostic and therapeutic) decreased by 69% in June 2020 and 44% in October 2020, compared to the average number of procedures performed before the COVID-19 pandemic, varying markedly between regions and countries, with the greatest regional decreases in Latin America. Significant reductions affected about 77% and 64% of conventional diagnostic procedures, 79% and 47% of PET, and 70% and 50% of therapeutic procedures in June and October, respectively. The impact was bigger in Latin America compared to Africa, both in June and October. Similar findings have been reported in a recent survey examining the impact of COVID-19 on Nuclear Medicine services in 2020 compared to 2019.¹⁴ There was an overall improvement in the significant reduction in nuclear medicine procedures observed in the first three weeks of the COVID-19 pandemic; however, there was no recovery of the previously discontinued services.¹⁵ Also, the reduction in diagnostic and therapeutic procedures of benign diseases was particularly severe.¹⁴

The interpretation of these changes can be attributed to reasons similar to those in the April 2020 survey; modifications in workflow scheduling, reduction in appointments, patients' reluctance to visit a medical center because of safety concerns, delay of non-urgent studies, delay of surgical procedures and pre- or perioperative assessments, shortages of essential supplies, introducing measures of infection prevention and control (IPC) including social distancing and decreasing the number of healthcare workers at a certain time to reduce staff exposure, and increasing the time allocated to each patient to include more exhaustive disinfection and cleaning procedures.¹⁰

Moreover, the reduction in diagnostic procedures was greater for conventional nuclear medicine studies (thyroid, cardiac, bone, and lung scans) than for PET/CT scans in Africa, but in Latin America this was the case only in October; in June the results were the opposite, showing a larger decrease in PET/CT than in conventional nuclear medicine. The reason behind these differences may be explained by: (a) the supply of the radionuclides since whereas PET tracers are produced in local cyclotrons, in the case of the supply of ^{99m}Tc/⁹⁹Mo generators and other radioisotopes most countries depend on international flights, except South Africa that has its own reactors for generating radionuclides; (b) the preferential scheduling assigned to oncological procedures (as is the case in most PET/CT procedures) given the more urgent nature of cancer assessments; and (c) the marked severity of the first wave in Latin America with severe lockdowns and postponement of non-COVID-19 patients. In Africa, many nuclear medicine departments had to stop their clinical activity completely because there was a complete interruption in the supply of radiopharmaceuticals.

When analyzing the clinical indications for referral to both conventional nuclear medicine and PET/CT, in Africa the reduction in exams was quite uniform for all studies, whereas

in Latin America the greatest reduction in exams was seen for myocardial perfusion and non-oncological studies. On one hand, the differences between Africa and Latin America could relate to different intensities of the COVID-19 waves in these two areas at these time-points. Also, discrepancies may represent the fear of the patients of being exposed to the virus in healthcare settings and, as mentioned previously, to certain procedures being considered less urgent. Compared to previous surveys,¹⁰ the global decrease was greater, probably because these LMICs may have had less resources to try to overcome the difficulties. In particular, the fluctuating modifications in the availability of technetium or gallium generators and of radiopharmaceutical delivery in general were most detrimental to the continuity of services in LMICs, showing greater insufficiencies in supplies of radioisotopes, generators, and kits.

It should be underlined that some centers reported an increase in their activities for conventional nuclear medicine diagnostic procedures: in Africa the activity was higher than baseline in 4% and 22% of cases, in June and October 2020, respectively; in Latin America the activity was higher in 8 and 11% of cases, in June and October 2020, respectively. Regarding PET/CT, centers reporting an increase in their activities were in Africa where the activity was higher than the baseline in 5% and 18% of cases, in June and October 2020, respectively; and in Latin America where the activity was higher in 2% and 17% of cases, respectively. These figures show that LMICs presented a trend towards recovering previous activities.

When focusing on radionuclide therapies, in Africa the main decreases were reported in radioiodine therapies for bone palliation, followed by benign thyroid disease and thyroid cancer, whereas in Latin America the reductions were more pronounced for benign thyroid disease, followed by thyroid cancer, PPRT, PSMA and bone palliation, similar to the findings in the previous survey.¹⁰ In contrast to the previous survey in which the results showed less affected procedures, such as selective internal radiation therapy, peptide receptor radionuclide therapy, and prostate-specific membrane antigen radioligand therapy, in Africa and Latin America selective internal radiation therapy, peptide receptor radionuclide therapy, and prostate-specific membrane antigen radioligand therapy presented reductions similar to the other procedures.

Incorporating IPC protocols is essential to protect healthcare workers and patients while continuing to provide medical services.^{7,8,16-18} In that aim, maintaining an adequate stock of PPE is critical. In our survey, 40% and 36% of centers in June and October 2020, respectively, reported shortages of PPE, with differences between Africa and Latin America. Whereas Africa reported shortages of PPE in 12% and 11% of centers in June and October 2020, respectively, in Latin America the reported shortage of PPE was 37% and 34%, respectively. The reasons behind these differences may relate to the lower number of procedures performed in Africa in comparison with Latin America. Regarding the 50% rate reported in the previous survey done in April,¹⁰ the trend of a general return to normality is evident, given the

improvement in the supply chain. Similarly, COVID-19 infections in staff were reported in 58% of surveyed centers, with Latin American centers being more impacted than African ones.¹⁰

The globally significant decrease in nuclear medicine procedures also resulted in a reduction of working hours in 56% of the responding centers, affecting two thirds of staff.

The decrease of essential supplies was very frequently reported for Africa and Latin America. Surveys conducted by international bodies such as the IAEA underpin the need to facilitate uniform and consistent supplies of radioisotopes in all countries, including generators, and kits to mitigate an increase in regional imbalances in service delivery. This will facilitate recovery to prepandemic clinical activity levels and will set the required basement upon which to build stronger healthcare systems, able to meet more complex healthcare demands and concurrently provide essential educational, research and developmental activities.

Conclusion

An April 2020 IAEA global survey to gauge the early impact of the COVID-19 pandemic on nuclear medicine was followed by a comparative survey in June and October 2020, presented here with focus on Africa and Latin America. These regions endured severe waves of the pandemic. This more recent survey, with 124 responding centers, represents a small but reliable sampling of existing nuclear medicine centers in Africa and Latin America. The data provides a global bird's-eye view on how these LMICs' nuclear medicine services are being affected by the COVID-19 pandemic.

When analyzing the different nuclear medicine procedures, the impact was more pronounced in Latin America than in Africa. PET/CT for oncologic indications showed a lesser decrease in utilization rates than did conventional nuclear medicine in Africa, but in Latin America this was the case only in October, but in June the results were reversed, with a larger decrease in PET/CT procedures compared to conventional ones. Regarding radionuclide therapies, in Africa the main decreases were reported in radioiodine therapies for bone palliation, followed by benign thyroid disease and thyroid cancer, whereas in Latin America the reductions were more marked for benign thyroid disease, followed by thyroid cancer, PPRT, PSMA and bone palliation. The survey shows a decrease of essential supplies frequently reported for Africa and Latin America, underpinning the need to make sure all countries receive uniform and consistent supplies of medical equipment.

In summary, 2020 saw a significant decrease in nuclear medicine diagnostic and therapeutic procedures due to pandemic-related challenges. The negative impact is significantly more pronounced in LMICs such as in Africa and Latin America. In June, the global decline recorded in the survey was greater than in October when the situation began to show improvement. However, the total number of procedures remained below the volumes normally conducted prepandemic.

The current COVID-19 pandemic poses many challenges for the practice of nuclear medicine. If adequately prepared, departments can continue to deliver their essential services, while mitigating the risk for patients and staff. This requires adapting the SOPs, as quickly as possible, to meet the new requirements.

Compliance With Ethical Standards

Research involving human participants and/or animals

Informed consent: this survey on nuclear medicine activities do not implies directly patient participation.

Ethical approval: This article does not contain any studies with human participants performed by any of the authors

Declaration of Competing Interest

Francesco Giammarile declares that he has no conflict of interest.

Roberto C. Delgado Bolton declares that he has no conflict of interest.

Noura El-Haj declares that she has no conflict of interest.

Miriam Mikhail declares that she has no conflict of interest.

Olga Morozova declares that she has no conflict of interest.

Pilar Orellana declares that she has no conflict of interest.

Olivier Pellet declares that he has no conflict of interest.

Enrique Estrada L. declares that he has no conflict of interest.

Yaroslav Pynda declares that he has no conflict of interest.

Diana Paez declares that she has no conflict of interest.

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