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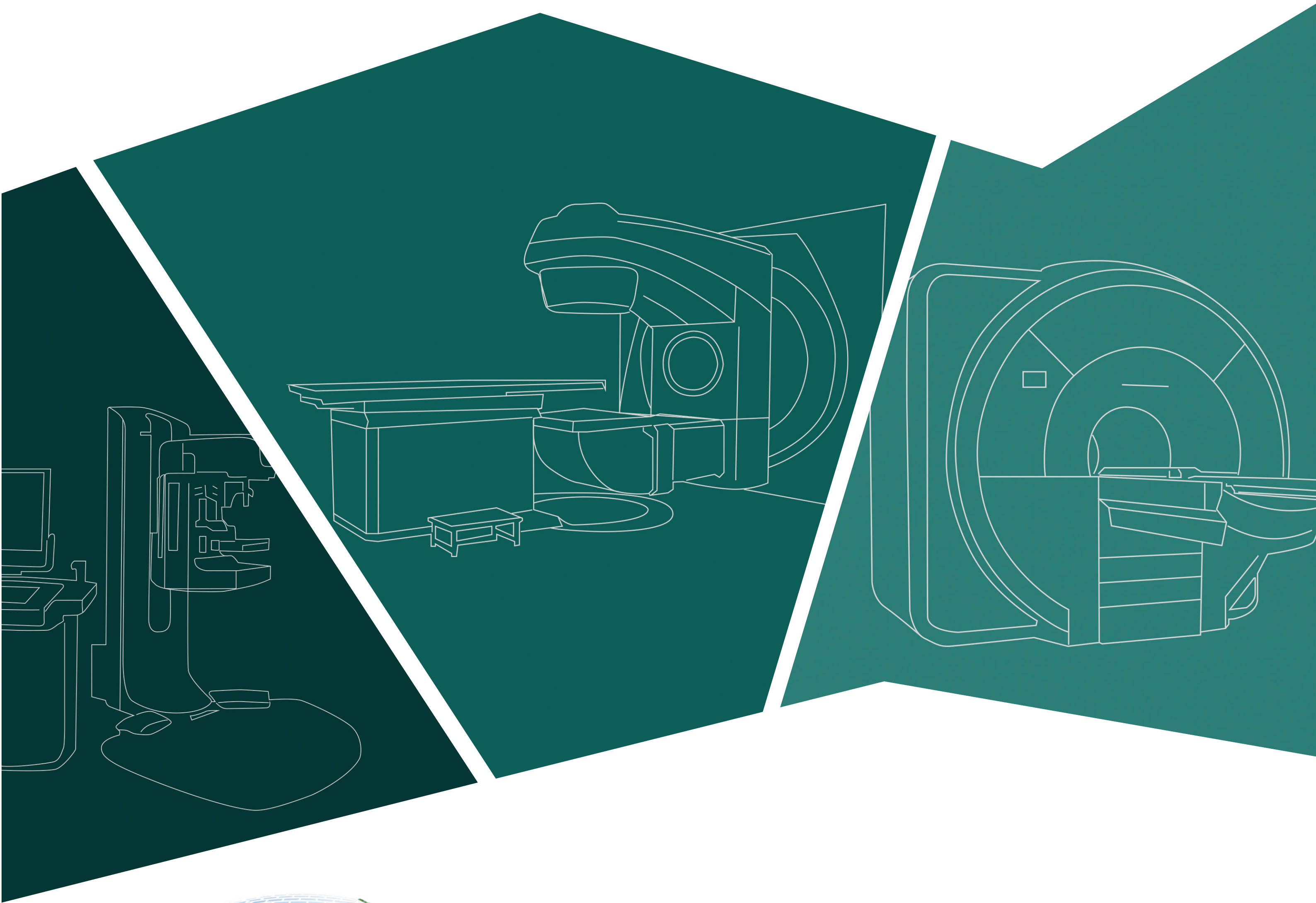
Rationalizing distribution and utilization of high value capital medical equipment in Greece



Assesment report

With funding by
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This document was produced with the financial assistance of the European Union. The views expressed herein can in no way be taken to reflect the official opinion of the European Union.

ABSTRACT

This report presents the results of an assessment of the distribution and utilization of high value capital medical equipment in Greece, including detailed analysis of the regional distribution, use and costs for specific categories of equipment. Having highlighted the major distortions identified, the authors propose specific policy recommendations for efforts to be focused on improving investment planning for high value capital medical equipment and developing health technology assessment (HTA) capacities related to medical devices. Additional recommendations stress the importance of promoting evidence-based decisions for procurement; putting in place a well-structured medical equipment inventory; improving maintenance through the development of biomedical/clinical engineering departments in Greek hospitals and their adequate staffing; and adopting clinical guidelines. The assessment is part of a series of activities outlined in the context of the collaboration between WHO Regional Office for Europe and the Ministry of Health to strengthen the health system in Greece, financially supported by the Structural Reform Support Service of the European Commission.

KEYWORDS

DELIVERY OF HEALTH CARE
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Abbreviations

CMMS	computerized maintenance management system
Co-60	Cobalt-60
CR	computed radiography
CT	computed tomography
DR	digital radiography
DRG	diagnosis related group
ECRI	ECRI Institute (previously Emergency Care Research Institute)
EEAE	Greek Atomic Energy Commission
EEPI&MA	Hellenic Society of Nuclear Medicine & Molecular Imaging
EKAPTY	National Evaluation Center of Quality and Technology in Health
ELEVIT	Hellenic Society of Biomedical Technology
EOPYY	National Organization for Healthcare Provision
GDP	gross domestic product
GMDN	Global Medical Device Nomenclature
HAMP	Hellenic Association of Medical Physicists
HTA	health technology assessment
HVCE	high value capital equipment
INBIT	Institute of Biomedical Technology
LINAC	linear accelerator
MDD	medical device directive
MDR	medical device regulation
MU	mammography unit
MRI	magnetic resonance imaging
NICE	National Institute for Health and Care Excellence
OECD	Organisation for Economic Co-operation and Development
OTAE	Federation of Technologists Radiologists of Greece
PET/CT	positron emission tomography/computed tomography
RT	radiotherapy
SEIV	Association of Health – Research & Biotechnology Industry
SPECT	single photon emission computed tomography
γ-camera	gamma camera

Acknowledgements

This report was produced through the Grant Agreement between the European Union, represented by the European Commission and the World Health Organization (WHO) on the action entitled Strengthening Capacity for Universal Coverage Greece/Phase 2 (SCUC2). The general objective of the Action is to contribute to improving health and health equity in Greece, by helping the Greek authorities to move towards universal coverage and to strengthen the effectiveness, efficiency and resilience of the health system. An important area under SCUC2 is related to rationalization of distribution and utilization of high value capital medical equipment. In this context, the present report contains detailed analysis of the regional distribution, use and costs for specific categories of equipment, as well as highlights the general issues identified and provides specific policy recommendations.

The report was drafted by the Institute of Biomedical Technology (INBIT) led by Nicolas Pallikarakis, Professor of medical physics and Head of INBIT. He acted as senior local expert and the main author and liaised with all relevant persons and institutions involved. Aris Dermitzakis, Biomedical engineer at INBIT contributed significantly to data gathering, analysis and data visualization.

Overall coordination and guidance for the assessment has been ensured by the Division of Health Systems and Public Health (DSP) of WHO Regional Office for Europe, under the leadership of Hans Kluge, Divisional director. The final version of the report was revised by Hanne Bak Pedersen, Programme manager, Health Technologies and Pharmaceuticals Division of DSP; and Adriana Velazquez Berumen, Senior adviser on Medical Devices Innovation Access and Use, Medicines and Health products Department, Health Systems and Innovation, WHO Geneva.

The authors gratefully acknowledge the support of the local WHO Project Office in Athens: Silviu Domente, Senior adviser, Health Policy and Thanos Myloneros, National professional officer in planning the activities and their coordination with the Ministry of Health, design of the report and fruitful discussions with the authors; Vion Psiakis and Giannis Manasis, local consultants, who contributed with data cross-checking and technical insights; and Chryssa Baroga who provided administrative and logistical support at all stages.

The authors are grateful for the valuable contribution of the following stakeholders and scientific societies:

- Federation of Technologists Radiologists of Greece (OTAE)
- Hellenic Society of Biomedical Technology (ELEVIT)
- Hellenic Society of Nuclear Medicine & Molecular Imaging (EEPI&MA)
- Hellenic Association of Medical Physicists (HAMP)
- Association of Health – Research & Biotechnology Industry (SEIV)
- Hellenic Radiological Society (HELRAD)

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Report writing was undertaken in a continuous consultative process with relevant institutions and people, ending with a final workshop organized by the Ministry of Health and moderated by Georgios Giannopoulos, Secretary general. The authors gratefully acknowledge the participation of all stakeholders and key informants whose ideas, comments and inputs have been integrated in this report.

Introduction

Advances in biomedical research and the resulting development of new diagnostic and therapeutic methods, techniques and equipment have led to a radical change in current health-care delivery. Modern medicine is strongly dependent on technology and some medical specialties have emerged from these technological advances. According to the World Health Organization (WHO) definition, "the term 'health technologies' refers to the application of organized knowledge and skills in the form of devices, medicines, vaccines, procedures and systems developed to solve a health problem and improve quality of lives" (World Health Assembly, 2007). Hence, medical devices are categorized as health technologies, with high value capital medical technologies forming an important subgroup of this category.

In 2016, the value of the global medical device market was estimated to be more than €300 billion, with more than 500 000 medical technologies registered (MedTech Europe, 2016). Mobile applications are proliferating and new information technology sectors have emerged to analyse the thousands of terabytes of data generated every day, and transform them into useful information. Additionally, comprehensive management of medical technology has become necessary to ensure that it is used effectively, safely and by well-trained personnel.

The term high value capital equipment (HVCE) refers to high-tech medical devices that include all equipment considered costly in terms of both initial investment and operation; and requiring specially trained personnel, regular quality control and preventive maintenance and management procedures in order to function properly and safely. According to the Global Medical Device Nomenclature (GMDN) most of these devices belong to the diagnostic and therapeutic radiation technology category. This policy brief considers the following groups:

- mammography
- computed tomography (CT)
- magnetic resonance imaging (MRI)
- gamma camera (γ-camera)/single photon emission computed tomography (SPECT)
- positron emission tomography/computed tomography (PET/CT)
- radiotherapy (RT) units – e.g. linear accelerator (LINAC), Cobalt-60 (Co-60).

Undoubtedly, HVCE is an important health resource that plays a prominent role in enhancing the quality of health care. Global use of these groups is continuously expanding but in most developed countries, although rather long in comparison to other technologies, their mean lifespan does not exceed 10 years.

Across Greece, there are quite pronounced regional inequalities in the availability of some of these technologies. Some important organizational, policy and reimbursement procedures could also be considered problematic, leading to over-prescription and unjustified expenses. Notable examples include full implementation of the diagnosis related groups (DRGs) and limited use of guidelines for prescription of diagnostic imaging.

Health care in Greece is also characterized by a very active private sector. Over the last 20 years, public hospitals have lost their dominance in all the HVCE fields examined here, except RT. Rapid increases in the number of private diagnostic centres since the late 1990s led to significantly increased costs in 2000 and made it necessary to apply cutting and clawback procedures to restore a more realistic level of spending during the economic crisis. Currently, the situation is normalized through the implementation of strict rules and monitoring procedures imposed by the National Organization for Healthcare Provision (EOPYY), under the Memorandum of Understanding.[1]

The present study aims to:

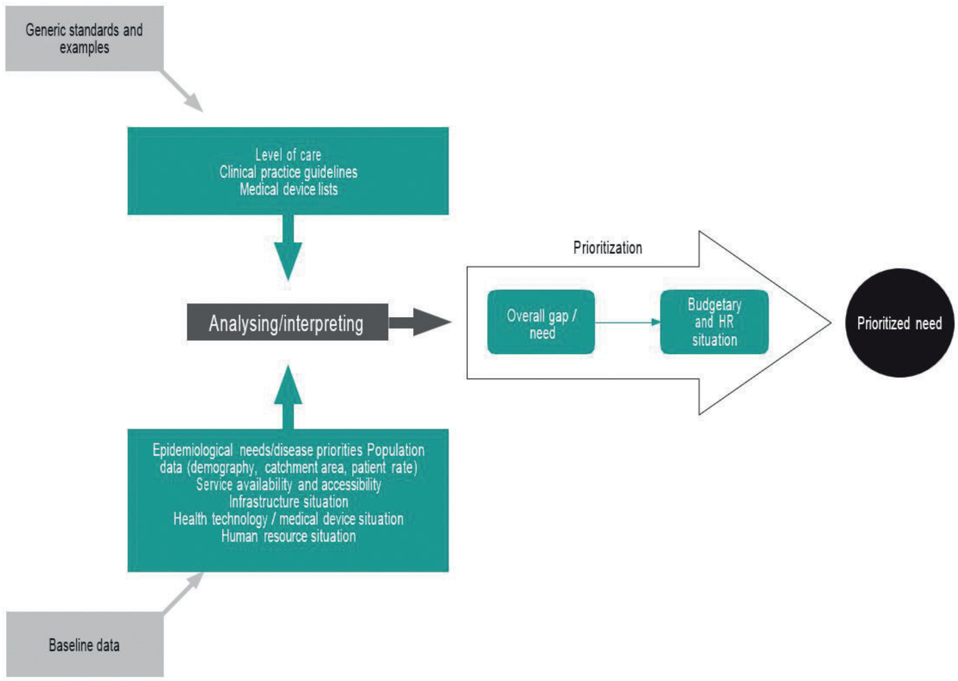
- assess the sufficiency of, and equity in, the distribution of HVCE and its use in Greece;
- identify eventual inequalities in terms of geographical coverage, specific needs and lack of HVCE;
- estimate the costs for use of HVCE;
- identify reasons for potential overuse;
- present proposals for improvement.

WHO has published a general approach for performing a needs assessment on the basis of existing and available equipment in a region or country, comparing it with what should be available, considering particular demand and needs, and taking account of epidemiological data, recognized standards and clinical practice guidelines (CPGs). By considering this alongside possible financial restrictions and the human resources available, the actual technological gap can be identified.

The whole approach is depicted in the general needs assessment diagram shown in Fig.1.

1 Memorandum of Understanding between the European Commission acting on behalf of the European Stability Mechanism and the Hellenic Republic and the Bank of Greece.

Fig. 1. WHO needs assessment diagram.



Source: WHO, 2011.

It is important to note that reliable baseline data on the existing situation and evidence-based assessment of needs are prerequisites for effective use of such a model.

In addition to the international scientific and technical literature, the standards and best practices in use and the current trends on these technologies, the general information sources for this report are data available from international organizations such as: WHO; Organisation for Economic Co-operation and Development (OECD), European Union (EU), National Institute for Health and Care Excellence (NICE), ECRI institute (ECRI) and other reliable web sources. There is no centralized national inventory for installed HVCE in Greece so the relevant information and data collected and used in this report are based on cross-referenced sources from the Greek Atomic Energy Commission (EEAE), National Evaluation Center of Quality and Technology in Health (EKAPTY), Hellenic Association of Medical Physicists (HAMP), Federation of Technologists Radiologists of Greece (OTAE) and the inventory for medical devices covering approximately half of the country performed in 2015 by the Biomedical Technology Unit of the University of Patras under an ESPA project. This creates a number of problems associated with data integrity, reliability and (in some cases) compatibility.

There are no available data related to the actual use of these technologies except for indirect information on those procedures that are reimbursed by EOPYY. However, these data do not present the whole picture of actual use and the associated expenditures since the numbers of diagnostic or treatment procedures not reimbursed by EOPYY are not known. Furthermore, the rebate and clawback procedures applied mean that EOPYY's data are also partial.

Finally, a number of interviews/discussions with medical specialists in the fields of radiology, RT and nuclear medicine; medical physicists; biomedical engineers; technologists and other specialists provided valuable input to this study.

The results on the distribution of HVCE in Greece and the intensity of use are presented in the next chapter. Notwithstanding the above-mentioned limitations, these results lead to a number of clear general conclusions and recommendations.

Findings

INTRODUCTION

In order to identify the difference between what exists and what is needed it is important to assess the current situation of HVCE in Greece. A country-wide medical equipment inventory including status and condition would be the ideal source but, given that no such general inventory exists, various sources have been used. This was necessary because most public hospitals in Greece not only lack health technology management systems but also rely on manufacturers to service these technologies. In addition, differences arise across the individual companies within the private sector. The data collected were compared against each other in order to obtain the most reliable picture.

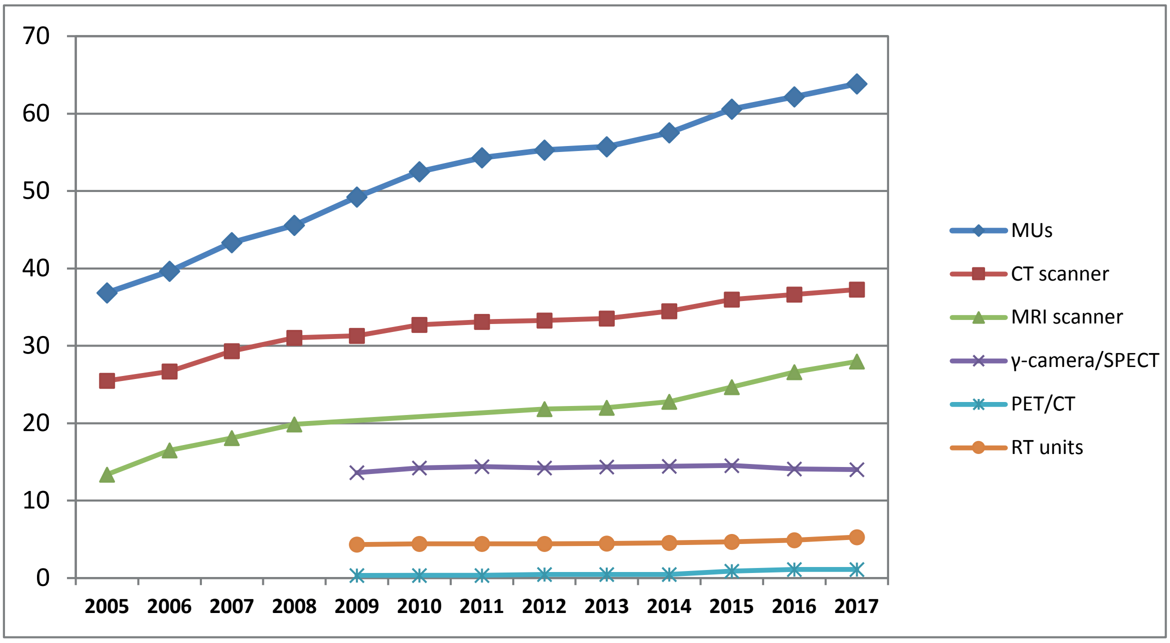
The data available from international organizations (e.g. OECD, WHO) rely on the initial source providing the information (e.g. EKAPTY, EEAE, professional societies) and therefore also present discrepancies in the numbers of equipment installed in Greece. This is because these different sources were not set up to provide a continuously updated and reliable medical devices inventory, but for other more specific reasons. For instance, the EEAE database (considered the most reliable) focuses on licensing and radiation safety issues and does not gather information on the year of manufacture or of entry into service. Additionally, although new information is continuously added to the database, these updates are related to the periodic checks performed by the agency for radiation safety purposes that vary in frequency from one to five years. As a result, the database does not reflect the actual situation of the installed base (i.e. number of units actually in use) of these technologies at any moment.

Taking account of the various sources of information, this study focuses on the existing HVCE installed technology as of November 2017. Existing online information available at the EEAE website was cross-checked against that obtained from the other sources mentioned in the previous section, duplicate entries were deleted and any new data identified were added.

Overview of installed HVCE

The overall picture of HVCE in Greece differs according to the technology and the level of penetration of the private sector. In mammography, for instance, the private sector dominates and the total number of equipment currently installed is quite high. Conversely, PET/CT equipment is available only in the public sector in Athens and Thessaloniki, although the private sector is starting to show an interest. The time evolution of HVCE implemented in Greece for the period 2005–2017 is presented in Fig. 2; Table 1 shows the distribution of these technologies per million population. All data for the period 2005–2008 are taken from OECD databases and are available only in units per million inhabitants; absolute numbers of units were calculated using the populations shown in the table. Data for 2009–2017 come from EEAE.

Fig. 2. Time evolution of HVCE per million population in Greece, 2005–2017.



Source: data from OECD (2005–2008) & EEAE (2009–2017).

As shown in Fig. 2 and Table 1, the overall HVCE installed per million population in Greece increased constantly from 2005 to 2017. During the same time period this trend was followed by all HVCE technologies except γ-camera/SPECT, which remained constant.

A graphical representation of the distribution of HVCE throughout Greece is provided in Annex 4, using geographical maps.

Table 1. HVCE per million population in relation to GDP, 2005–2017.

Year	Population (millions)	Per capita GDP (€)*	MUs		CT scanners		MRI scanners	
			Units per million	Absolute number	Units per million	Absolute number	Units per million	Absolute number
2005	10.97	20 913	36.9	404	25.5	280	13.4	147
2006	11.00	22 029	39.7	436	26.7	294	16.5	182
2007	11.04	22 692	43.4	479	29.3	323	18.1	200
2008	11.06	22 556	45.6	504	31.1	344	19.9	220
2009	11.09	21 529	49.2	546	31.3	347	N/A	N/A
2010	11.12	20 324	52.5	584	32.7	364	N/A	N/A
2011	11.12	18 495	54.3	604	33.1	368	N/A	N/A

Year	Population (millions)	Per capita GDP (€)*	MUs		CT scanners		MRI scanners	
			Units per million	Absolute number	Units per million	Absolute number	Units per million	Absolute number
2012	11.09	17 238	55.3	613	33.3	369	21.8	242
2013	11.00	16 800	55.7	613	33.5	369	22.0	242
2014	10.93	17 038	57.5	629	34.5	377	22.8	249
2015	10.86	17 100	60.6	658	36.0	391	24.7	268
2016	10.78	17 176	62.2	670	36.6	395	26.6	287
Total units as of November 2017			**687**		**401**		**301**	

Year	Population (millions)	Per capita GDP (€)*	PET/CT		γ-camera/SPECT		RT	
			Units per million	Absolute number	Units per million	Absolute number	Units per million	Absolute number
2005	10.97	20 913	0.4	4	13.6	151	4.3	48
2006	11.00	22 029	0.4	4	14.2	158	4.4	49
2007	11.04	22 692	0.4	4	14.4	160	4.4	49
2008	11.06	22 556	0.5	5	14.2	158	4.4	49
2009	11.09	21 529	0.5	5	14.4	158	4.5	49
2010	11.12	20 324	0.5	5	14.5	158	4.6	50
2011	11.12	18 495	0.9	10	14.5	158	4.7	51
2012	11.09	17 238	1.1	12	14.1	152	4.9	53
2013	11.00	16 800	0.4	4	13.6	151	4.3	48
2014	10.93	17 038	0.4	4	14.2	158	4.4	49
2015	10.86	17 100	0.4	4	14.4	160	4.4	49
2016	10.78	17 176	0.5	5	14.2	158	4.4	49
Total units as of November 2017			**12**		**151**		**57**	

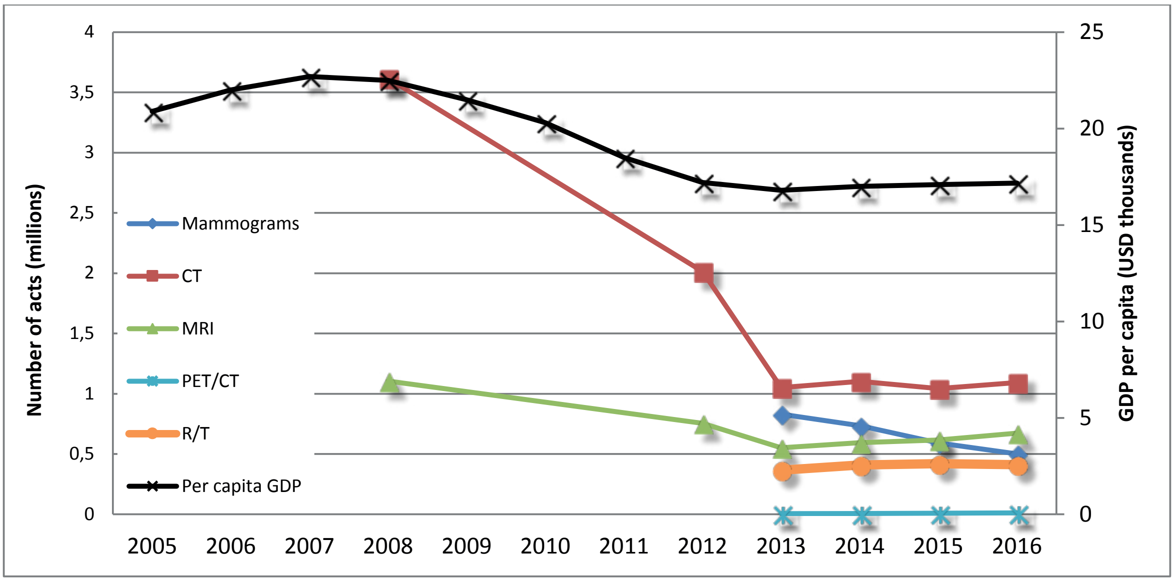
*Gross domestic product (GDP) calculated using constant local currency unit (LCU) (World Bank, 2017).
Source: data from OECD (2005–2008), EEAE (2009–2017) and World Bank, 2017.

From 2009 to 2017, the per million population numbers of mammogram, CT, MRI, PET and RT procedures rose by 30%, 19%, 28%, 175% and 19%, respectively. The population grew from 10.97 million to 11.12 million between 2005 and 2010; and per capita GDP increased from €20 913 in 2005 to a maximum of €22 692 in 2007 (World Bank, 2017). Both population size and per capita GDP declined thereafter – to 10.78 million and €17 176 respectively in 2016.

Overview of use and cost data

A general overview of the evolution of exams performed for all HVCE modalities is depicted in Fig. 3. It is important to notice the very pronounced decline in numbers of CT and MRI exams between 2008 and 2013; data available for 2013 onwards also show a reduction in the number of mammograms. Numbers of PET exams and RT acts remained stable between 2013 and 2016 but are expected to increase given the number of new RT and PET scanners installed during 2017.

Fig. 3. Time evolution of GDP and numbers of acts in different HVCE modalities, 2005–2016.



Source: data on acts from OECD (2008–2012) and EOPYY (2013–2016).

Comparison with other EU countries

According to Eurostat the availability of equipment for diagnosis has increased rapidly in most EU Member States during the past decade. Relative to population size and subject to data availability, the OECD report Health at a glance 2017 (OECD, 2017) states that, "Germany, Greece, Iceland, Italy, Korea and Switzerland also have significantly more MRI and CT scanners per capita than the OECD average" (concerns 2015 data). The report also states that Greece was already among the European countries with the highest numbers of MUs relative to population size in 2005. PET scanners are generally the least widely available imaging equipment. Most EU countries have achieved universal (or near-universal) coverage of health-care costs for a core set of services. However, in 2004 Greece was one of four EU countries (with Cyprus, Bulgaria and Romania) in which more than 10% of their population was not regularly covered for health-care costs by public (or private) health insurance. This may have changed recently.

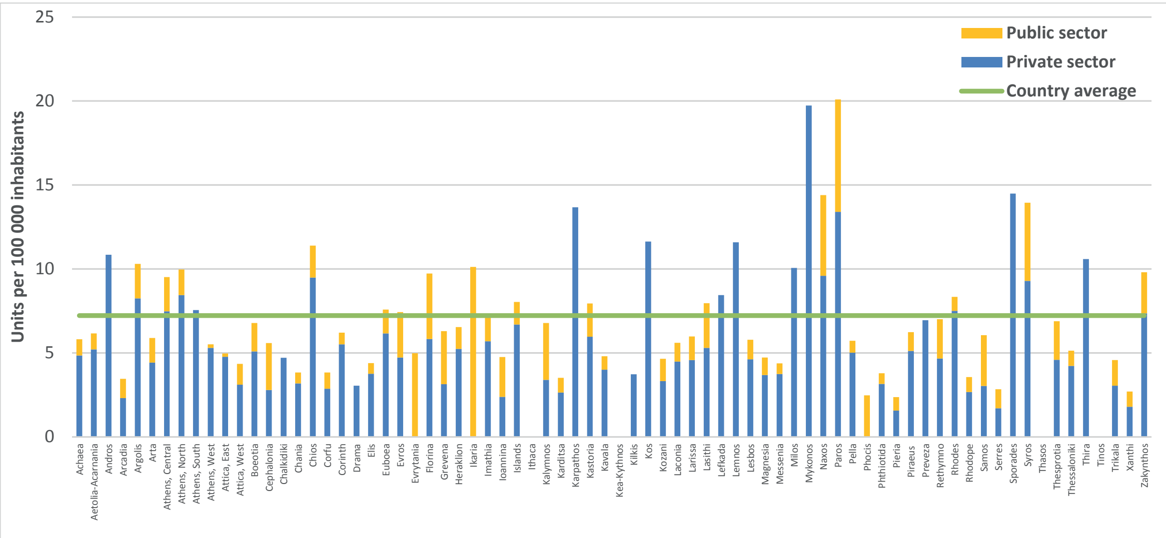
In the following sections the data for all different technologies covered in this study are analysed in more detail by either administrative regions or regional sectors, as appropriate. Development of the installed equipment base from 2005 to 2016 in four other EU countries with similar population sizes (Austria, Denmark, Finland and Portugal) was used for comparison.

MAMMOGRAPHY

Regional distribution

The regional sector distribution of MUs in Greece is shown in Fig. 4.

Fig. 4. Regional sector distribution of MUs per 100 000 inhabitants, 2017.

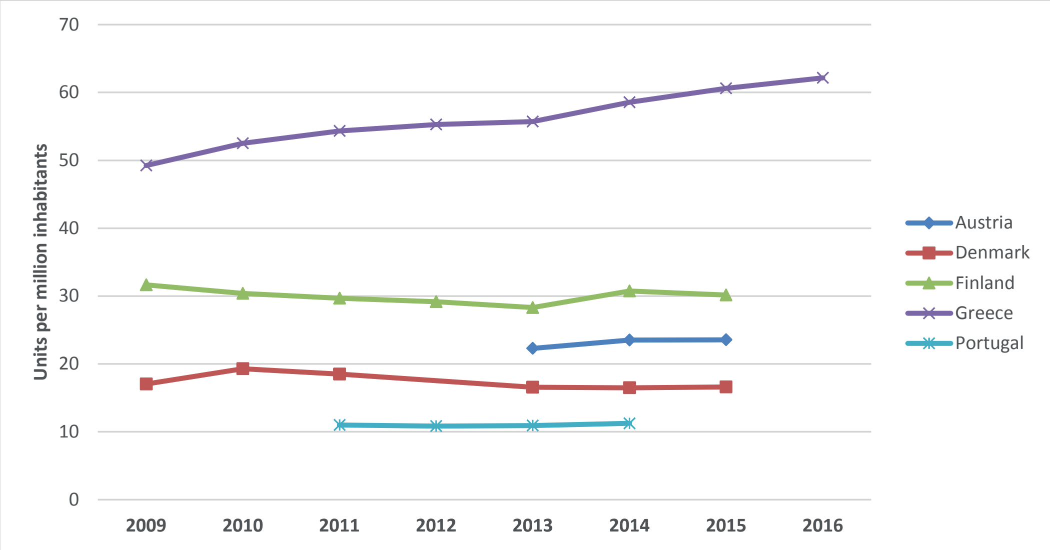


Source: data from EEAE.

It is apparent that MUs are available in most regional sectors in Greece. The few exceptions are found not only in the relatively small islands of Kea and Kythnos, but also in the much bigger and more highly populated islands of Thasos and Tinos. Hence, women in these regions who need mammograms must travel to another island or mainland Greece. The highest numbers of units per 100 000 inhabitants appear to be in the islands of Paros, Mykonos, Sporades and Naxos but this is because the metric is influenced by the low populations of these islands. Compared to the rest of the country, lower numbers of MUs per 100 000 inhabitants are shown in Phocis, Xanthi, Serres, Pieria and Drama. Most of these areas are located in the north east of the country, which lags behind other regions in numbers of MUs installed. The private sector has total cover of 14 regional sectors, 12 of which are islands. These include the island of Mykonos, which shows the second highest number of MUs per 100 000 population.

A comparison with four EU countries with similar-sized populations is presented in Fig. 5. The figure shows clearly that Austria, Denmark, Finland and Portugal have about half the number of MUs operating in Greece. This may be due to population density, the large number of remote small cities and the large number of islands in Greece. It implies that units had to be installed in areas with low populations in order to assure accessibility. In fact, Austria, Denmark and Portugal have much denser populations and smaller distances to medical centres. This assumption is supported by the fact that Finland has a much lower population density than Austria, Denmark or Finland, but is second only to Greece in equipment numbers.

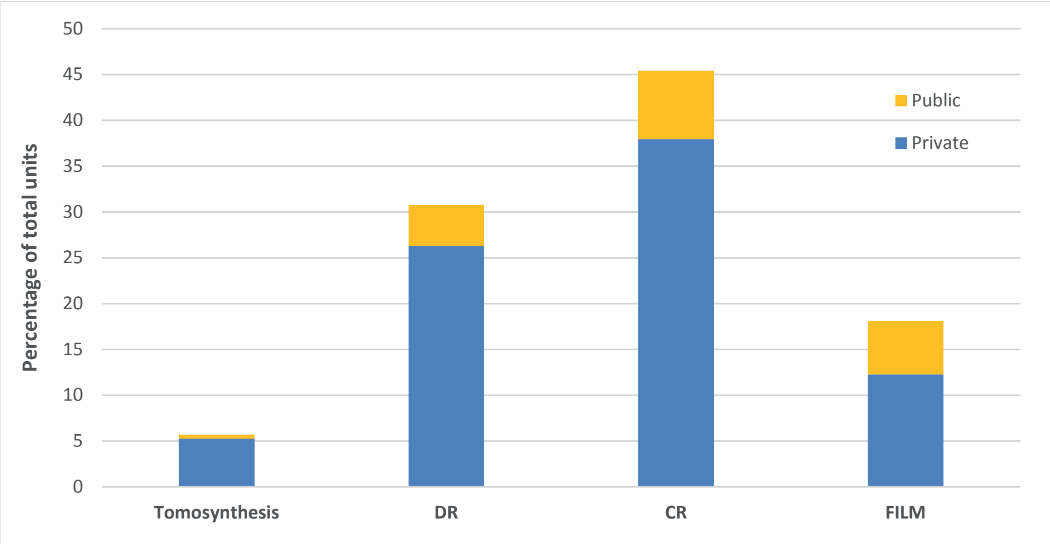
Fig. 5. MUs per million inhabitants: comparison with four EU countries, 2009–2016.



Source: data available from OECD (2005–2008) & EEAE (2009–2017)

Distribution of the four major mammographic technologies is presented in Fig. 6. Tomosynthesis represents only just over 5% of total units, provided in only three public hospitals and 36 private-sector institutes. The dominant technology is computed radiography (CR), covering approximately 45% of the installed units; digital radiography (DR) is available in about 30%; and about 18% of units are still film based.

Fig. 6. Distribution of the four major mammographic technologies, 2017.



Source: data from EEAE.

Use and cost

The evolution of the number of mammograms and the associated reimbursement costs over the period from 2013 to 2016 are shown in Table 2, based on data provided by EOPYY. The market share dominated by the private sector shows a shift towards the public sector and towards fewer exams (almost 50% less).

Table 2. Analytical data, evolution and comparison of number of mammography exams, installed units and costs reimbursed by EOPYY, 2013-2016.

Year	No. exams per year					No. units	Average no. exams per unit per year
	Public		Private		Total		
2013	103 380	12%	727 004	88%	830 384	613	1355
2014	110 022	15%	624 788	85%	734 810	629	1168
2015	116 388	20%	474 885	80%	591 273	658	899
2016	131 237	26%	369 418	74%	500 655	670	747

Year	Total EOPYY expenditure per year (€)					EOPYY reimbursement per exam (€)	
	Public		Private		Total	Public	Private
2013	827 887	14%	5 022 878	86%	5 850 765	8	7
2014	880 903	17%	4 329 421	83%	5 210 324	8	7
2015	932 268	22%	3 285 907	78%	4 218 175	8	7
2016	1 108 175	29%	2 659 958	71%	3 768 133	8	7

Source: data provided by EOPYY.

In 2013, only 12% of mammograms were performed in the public sector; by 2016 this share had increased to 26%. However, this is only partly due to the almost 30% increase in mammograms performed in the public sector and is mostly the result of an overall significant decrease (40%) in the total number of exams performed in 2016 compared to 2013. It is also important to note that digital mammography was previously paid out of pocket but has been reimbursed by EOPYY since February 2017. The data presented here show the exams reimbursed by EOPYY and could explain the marked drop in the number of exams.

As reported by the OECD, Table 3 shows the percentages of total mammograms performed for screening purposes in the four comparator countries and Greece.

Table 3. Percentages of mammograms for screening purposes: comparison with four EU countries.

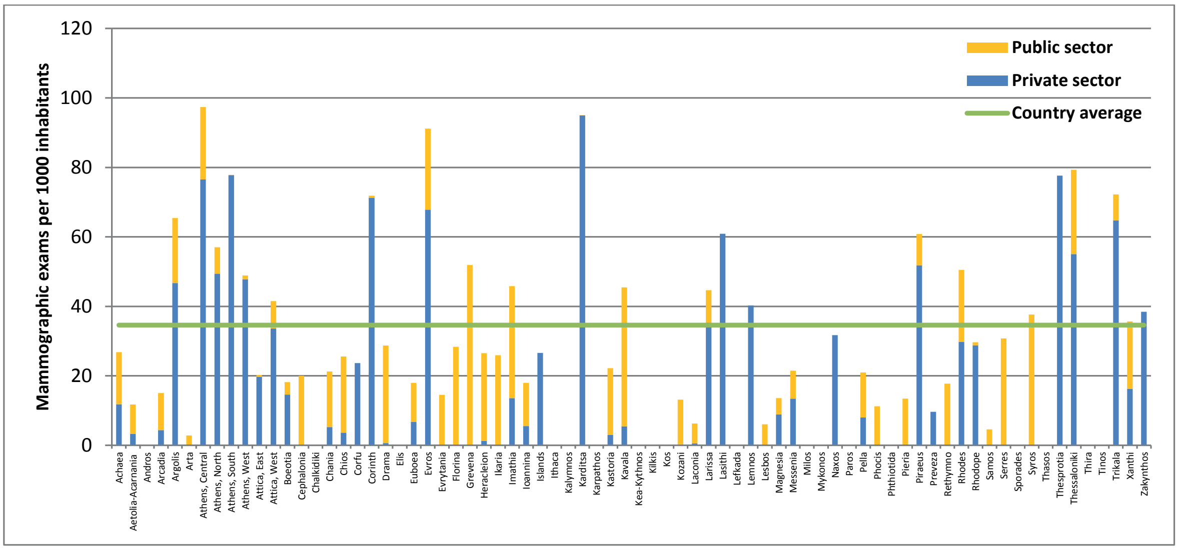
Country	First measurement		Second measurement	
	Year	% of total for screening	Year	% of total for screening
Austria	2006	80.2	2014	72.7
Denmark	2008	73.7	2014	83.9
Finland	2004	87.4	2014	82.8
Greece	2006	53.8	2009	49.5
Portugal	2005	73.6	2014	84.2

Source: data available from OECD

Two main conclusions can be drawn from this table. Firstly, as already mentioned, data availability and analysis in Greece lags well behind other EU countries – in this case the most recent data available are for 2009. Secondly, mammograms for screening purposes in Greece had far lower percentages than the other EU countries.

The distribution of mammograms per 1000 inhabitants per regional sector in 2016 (Fig. 7) reveals big differences amongst regions, in spite of equipment availability.

Fig. 7. Regional sector distribution of mammographic exams per 1000 inhabitants, 2016.

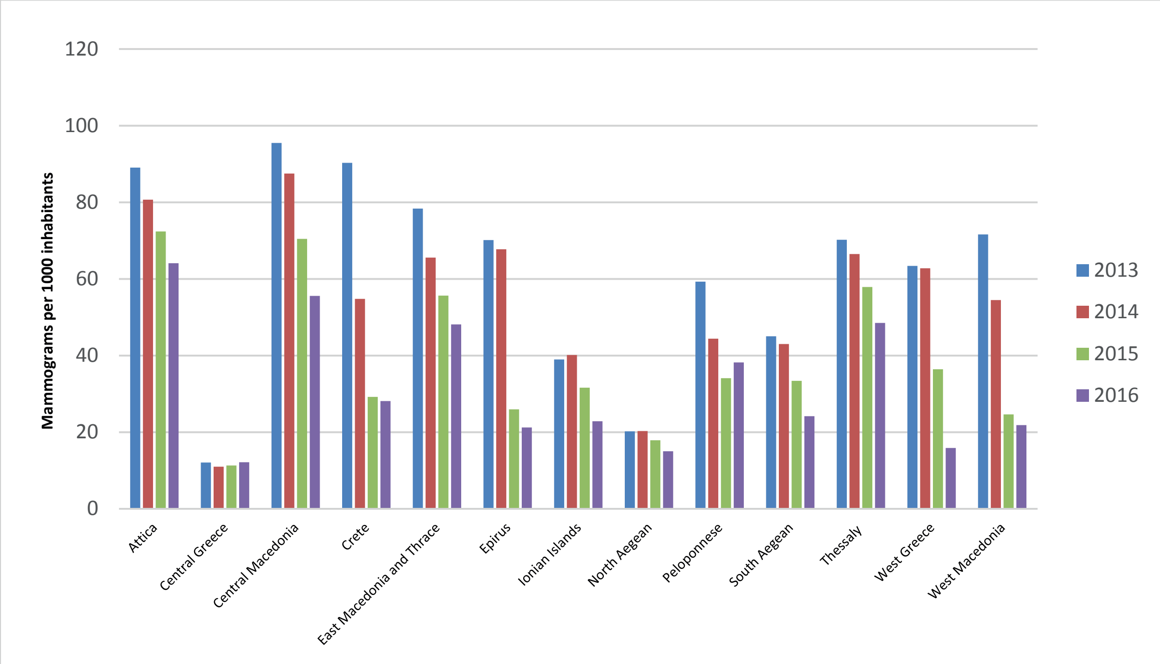


Source: data provided by EOPYY

The number of mammograms performed per regional sector shows much greater discrepancies than the distribution of MUs. Also, numbers of exams per thousand inhabitants are significantly higher in some areas and extremely low in others.

Looking at the time evolution of the number of mammograms per 1000 inhabitants per region during the 2013–2016 period (Fig. 8), it is clear that the whole regions of Central Greece and North Aegean lag substantially behind the other regions.

Fig. 8. Time evolution of number of mammograms per 1000 inhabitants in each administrative region, 2013–2016.



Source: data available from EOPYY.

Additionally, large drops in the number of exams can clearly be seen throughout the country. This is in accordance with the data shown in Table 2 and indicates that a large number of women are not participating in the preventive screening programmes. As already mentioned, part of this drop can be explained by charges for digital mammography moving from out-of-pocket payments to reimbursement by EOPYY in February 2017. The drop in the number of exams in West Greece is particularly remarkable and difficult to explain.

Data analysis and discussion

The number of MUs in service is considered well above what would be necessary under the screening recommendations, although it is observed that their density shows considerable variation across the country. High numbers of MUs may have undesirable consequences such as insufficient experience in the interpretation of mammograms for optimal sensitivity and specificity. Also, broadening of age ranges and frequency with which mammography is offered and therefore increased costs, as reported by Autier and Ouakrim (2008). In their study they assessed the number of MUs in 31 European, North American and Asian countries where significant mammography activity has existed for over 10 years, collecting data on the number of such units and of radiologists by contacting institutions in each country likely to provide the relevant information. Around 2004, there were 32 300 MUs in 31 countries; the number per million women ranging from less than 25 to more than 80 units, with Greece being in the upper limit (Autier & Ouakrim, 2008). However, this does not seem to be the situation in Greece – EOPYY data indicate that the private sector currently represents approximately 70% of the market, demonstrating a significant drop of 20% when compared to 2013. The installed base shows clearly that the private sector invested heavily in mammography over the last 10 years. However, it is important to note that this has now stopped, probably due to the small profit margin – the EOPYY reimbursement of €7 per mammogram in the private sector, plus the patient contribution of 15% results in a total of €8.24 per mammogram. This leaves a very small, if any, margin of profit for the private sector. In percentage terms this has led to a shift of exams to the public sector.

When the absolute number of mammograms performed is considered, there appears to be a problem in the Greek breast-cancer screening programme. Between 2013 and 2016, the total number of mammograms reimbursed by EOPYY fell by almost 40% from 830 384 to 500 655. In absolute numbers, over the same period the number of mammograms performed in the public sector increased by 27 857 exams, while the private sector shows a very pronounced decrease from 727 004 to 369 418. According to the EOPYY data, it appears that a considerable number of women did not have a mammogram. The 2011 census shows approximately 1.3 million women in the 50–69 age range in Greece. Assuming that these populations should have at least one mammogram every two years, more than 700 000 mammograms should be performed for screening purposes alone. In 2016 there was a total of 500 655 mammograms, meaning that the number for screening purposes is considerably lower than expected. If the data in Table 3 are taken into account, the percentage of mammograms for screening in 2009 was approximately 50%. Assuming that this number is still more or less the same, and given that Greece's population is fairly constant, it could be said that about 250 000 of the 500 000 mammograms performed are for screening – close to one third of the expected number.

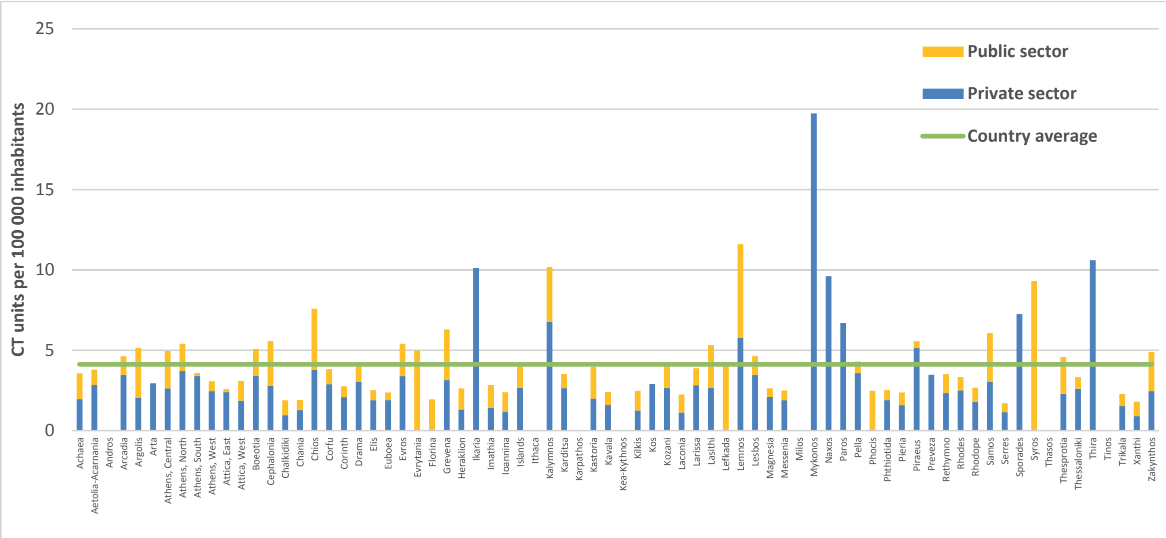
The number of exams reported by EOPYY does not accurately represent the overall picture since a percentage of patients pay out of pocket to use private sector services that are not reimbursed by EOPYY. For instance, Lefkada Island appears to have no exams at all but this is because the only facility is a private mammography unit. In such cases patients pay prices far higher than the EOPYY reimbursement.

International recommendations and guidelines on the ages and frequency at which mammographic exams should be performed have become quite controversial. There is uncertainty about the magnitude of overdiagnosis, associated with different screening strategies and partly attributable to lack of consensus on estimation methods (Myers et al., 2015). It should also be mentioned that 63% of the total units installed are using the outdated or superseded technologies of film and CR imaging. Compared to DR, the CR technology was recently reported as failing to image benign lesions and malignant calcification clusters in some cases, resulting in reductions in cancer cases detected of 15% and 22%, respectively (Myers et al., 2015).

Regional distribution

The regional sector distribution of CT units in Greece is shown in Fig. 9. Generally most of the regional sectors show smaller fluctuations in the number of CT scanners per 100 000 inhabitants, but some stand out clearly.

Fig. 9. Regional sector distribution of CT units per 100 000 inhabitants, 2017.

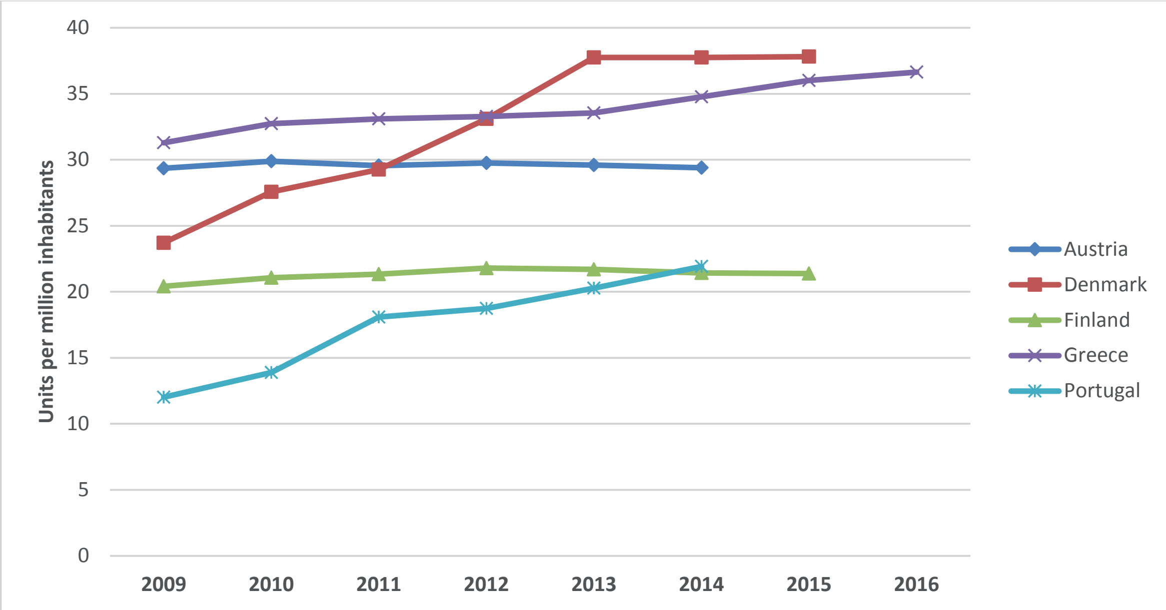


Source: data from EEAE.

Although the total number of units is large, it is observed that several areas have no CT scanner – Andros, Ithaca, Kea-Kythnos, Milos, Thasos and Tinos. These areas are all islands so, depending on their condition, any patient needing a CT scan has to travel or be transferred to another island or mainland Greece. Conversely, some regions appear to have twice the number of CT scanners per 100 000 inhabitants than the rest of the country's regions. Again, these are mostly islands – Mykonos, Lemnos, Syros, Sporades, Thira, Ikaria, Kalymnos, Chios, Naxos – where the presence of even one or two CT scanners highly increases their ratio of units per 100 000 inhabitants, due to their small populations.

It is also interesting to note that four regions are fully covered by the private sector alone. Again, these are islands – Mykonos, Thira, Ikaria and Naxos. For Mykonos and Thira, this can be explained by their status as holiday destinations well-known throughout the world that attract large numbers of high-income tourists. This is not the case for Naxos and even less so for Ikaria. In all cases, patients in these areas who need CT scans and are not willing to travel are obliged to use a private centre.

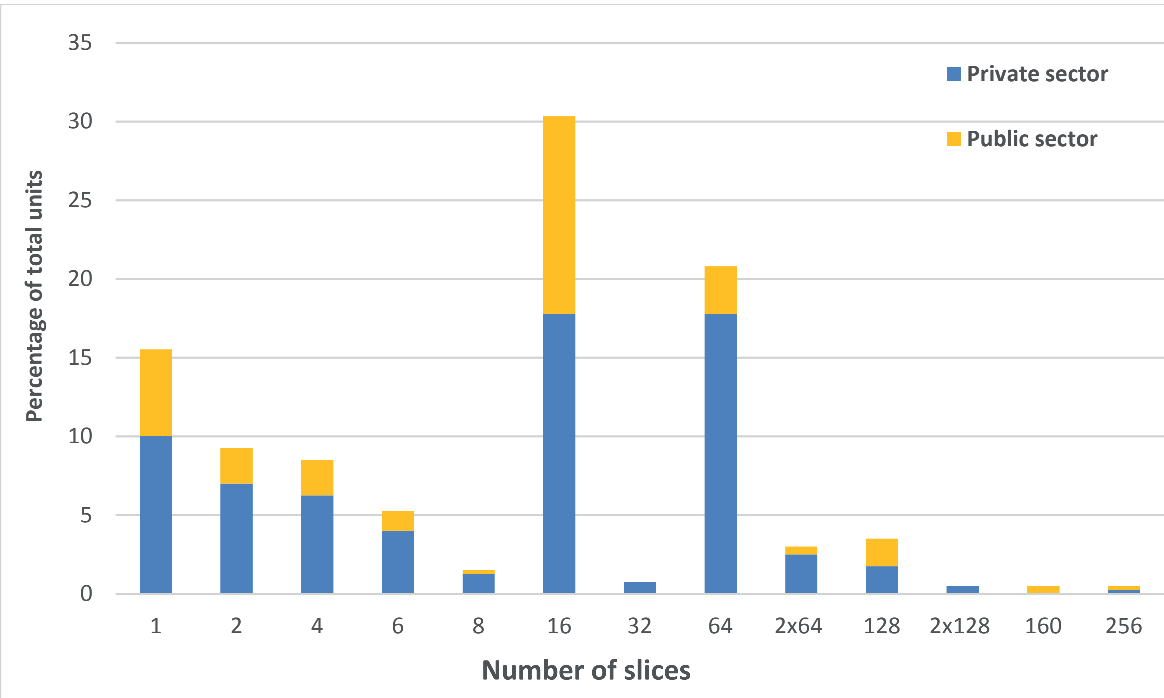
Fig. 10. CT scanners per million inhabitants: comparison with four EU countries, 2009–2016.



Source: OECD (other EU countries) and EEAE (Greece).

In comparison with the four comparator European countries, Greece has a high number of CT scanners in terms of the number of units per million inhabitants – equal to Denmark and almost double the number in Finland and Portugal, respectively.

Fig. 11. Distribution of installed CT units, by number of slices.



Source: data from EAAE.

The distribution of CT units based on the number of slices acquired is shown in Fig. 11. This was an effective method for indirectly estimating the age of scanners, since manufacturing date data and the technological status of the installed units were not available in all cases. As shown, the most dominant technology is 16 slices (around 30% of total scanners), followed by 64-slice scanners (around 20% of total scanners). These two technology generations are not new but are still not outdated (especially the 64-slice technology) and comprise more than 50% of CT scanners installed. Conversely, it is noticed that the third most common technology is one-slice CT scanners, followed by two-, four- and six-slice scanners – most of these very old and outdated technologies are available in the private sector. It is important to state that in discussions medical doctors pointed out that, even though obviously old, these scanners can still have diagnostic value when 3D volume imaging is not needed. In general, approximately 70% of the total CT scanners installed are below 64 slices and only a few new high-end scanners are available, indicating that rather aged units are installed in the country.

Use and cost

The evolution of the number of CT exams and associated reimbursement costs from 2013 to 2016 are presented in Table 4 , based on data provided by EOPYY.

Table 4. CT imaging: analytical data, evolution and comparison of number of exams, installed units and costs reimbursed by EOPYY, 2013-2016.

Year	No. exams per year					No. units	Average no. exams per unit per year
	Public		Private		Total		
2013	255 918	24%	794 566	76%	1 050 484	369	2847
2014	271 622	25%	830 043	75%	1 101 665	377	2922
2015	257 574	25%	785 318	75%	1 042 892	391	2667
2016	251 553	23%	842 131	77%	1 093 684	395	2769

Year	Total EOPYY expenditure per year (€)					EOPYY reimbursement per exam (€)	
	Public		Private		Total	Public	Private
2013	17 470 577	33%	35 009 926	67%	52 480 503	68	44
2014	18 495 464	33%	36 723 221	67%	55 218 685	68	44
2015	17 636 519	33%	35 674 458	67%	53 310 977	68	45
2016	16 908 803	30%	38 753 036	70%	55 661 839	67	46

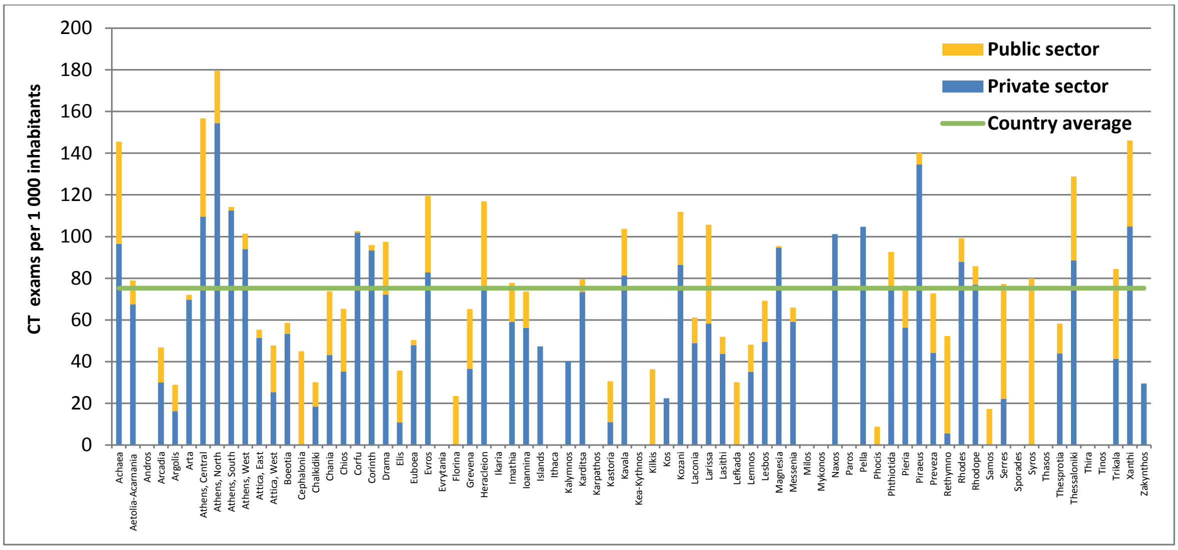
Source: data provided by EOPYY.

The CT imaging modality appears rather stable, in both the number of CT units installed and their use. Following a remarkable drop of almost 70% between 2008 and 2013, the number of CT exams remained stable during the period 2013–2016. There are very small fluctuations in the number of exams and the percentage of exams in the private and in the public sector. In general, only 25% of exams are performed in the public sector.

In terms of EOPYY reimbursement, the average cost of a CT scan is €68 when performed in the public sector and €45 in the private sector. The latter represents 85% of the total cost, with the remaining 15% paid by patients. However, no data were found concerning the number of exams performed and covered directly by either private insurance or out of pocket, without any EOPYY reimbursement. The same is true for exams of uninsured patients performed in public hospitals – these numbers may be quite large.

Numbers of CT exams per 1000 inhabitants (Fig. 12) appear to be higher in areas with big cities (Achaea, Heraklion, Ioannina, Thessaloniki) and in Xanthi. This is an expected result since generally most of these areas contain larger and better-equipped hospitals that treat patients and provide services to populations in neighbouring regions. The same applies for Athens and areas such as Larissa and the islands of Corfu, Lesbos and Rhodes where (as already mentioned) neighbouring islands may not have any CT scanners available.

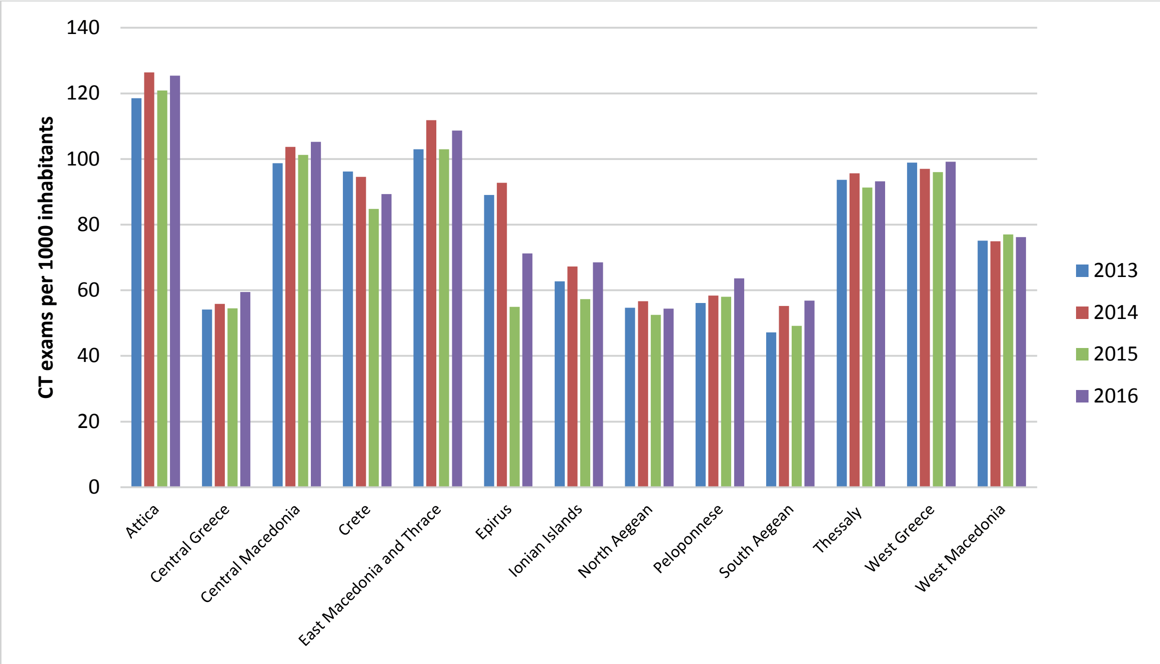
Fig. 12. Regional sector distribution of CT exams per 1000 inhabitants, 2016.



Source: data from EOPYY.

The time evolution of the number of CT exams remained relatively stable between 2013 and 2016 (Fig. 13). This is to be expected since CT imaging is a widely spread technology, its use stabilized through many years as the standard imaging technique for many cases. Regional distribution of CT use shows the lowest numbers of exams in the areas of Central Greece, Ionian Islands and Peloponnese.

Fig. 13. Time evolution of number of CT exams per 1000 inhabitants in each administrative region, 2013–2016.



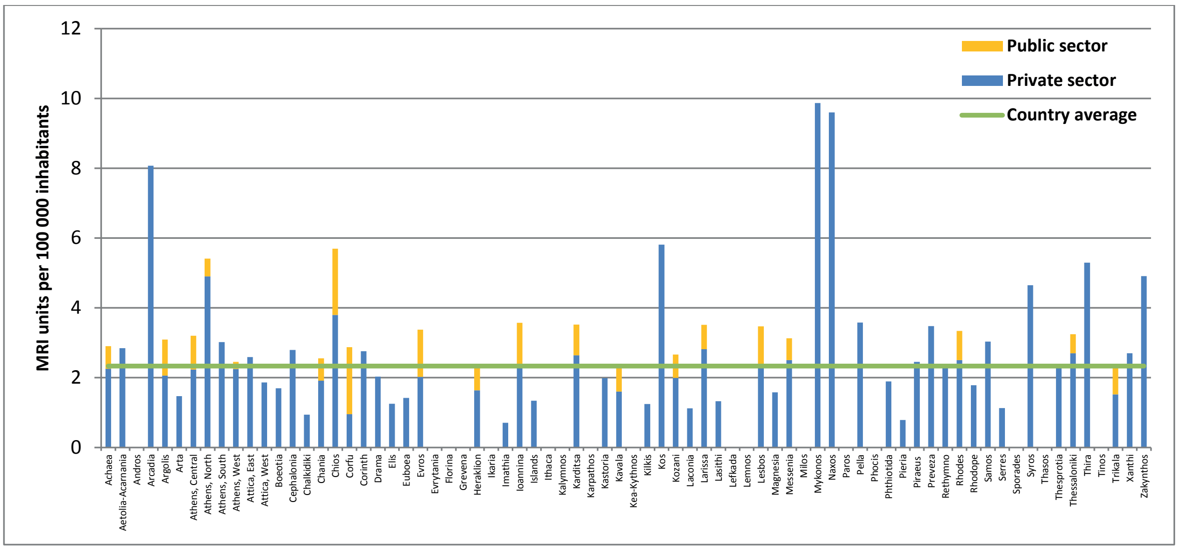
Source: data from EOPYY.

MRI

Regional distribution

The regional distribution of MRI units in Greece is shown in Fig. 14. This is more uneven than the distribution of CT scanners as there are many more regional sectors without MRI scanners: a total of 17, of which 12 are islands and five are on the mainland.

Fig. 14. Regional sector distribution of MRI units per 100 000 inhabitants, 2017.

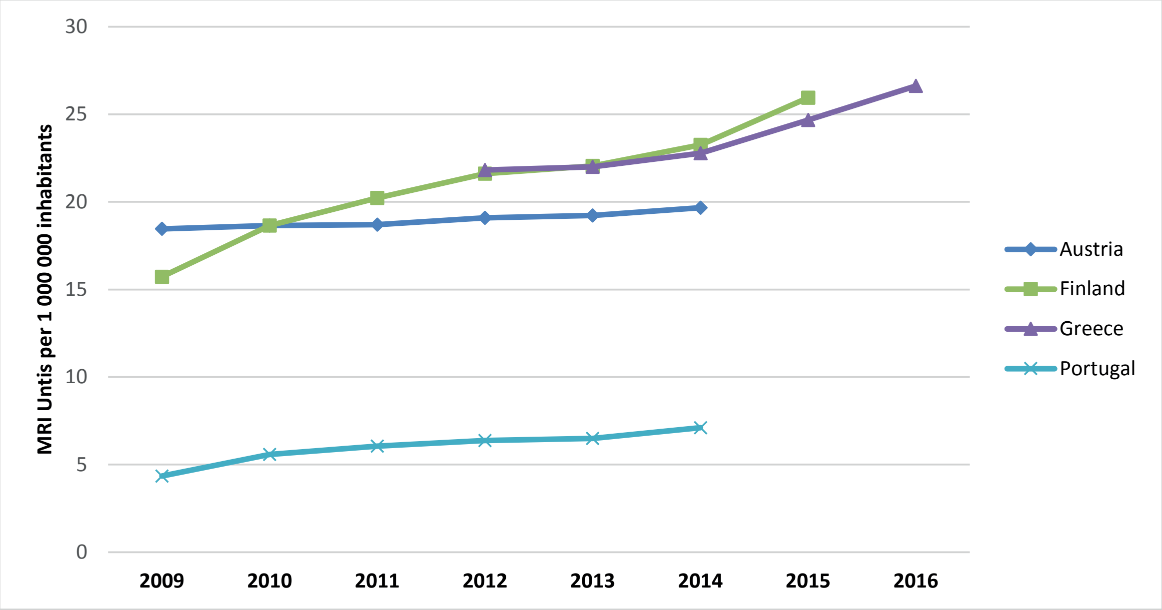


Source: data from EEAE.

Private-sector coverage of MRI imaging differs markedly from that of CT: 37 regional sectors are fully covered by the private sector alone. This finding is in accordance with the private sector's 90% market share in the number of MRI exams and the associated EOPYY reimbursements, as presented in the next section. The islands of Mykonos and Naxos have very high ratios of units per 100 000 population and both show 100% coverage by the private sector. This may be due to the large numbers of high-income travellers.

For MUs and CT scanners, Greece has one of the highest units to population ratios amongst the EU comparison countries in this study.

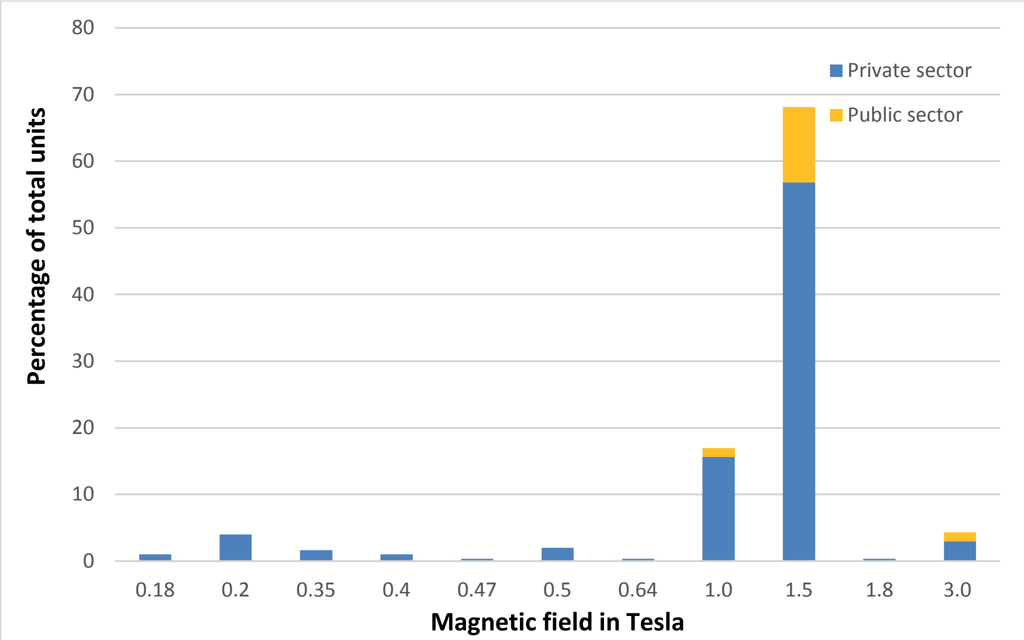
Fig. 15. Number of MRI scanners per million inhabitants: comparison with three EU countries, 2009–2016.



Note: data from Denmark not available. ***Source***: data from OECD (other EU countries) and EEAE (Greece).

Distribution of MRI units based on their magnetic field strength is presented in Fig. 16. This figure is a good index for the technological status of the installed units.

Fig. 16. Distribution of installed MRI units based on magnetic field strength.



Source: data from EAAE.

Although obviously not the only determinant factor, it is known that MRI scanners with stronger magnetic fields have the ability to produce higher resolution images and allow more advanced modern imaging techniques. In Greece, almost 70% of all installed MRI units are 1.5 tesla (T); 25% have a magnetic field of 1T or less (most in the private sector); and only 5% use a stronger magnetic field (3T). The latter are used mainly for research.

Use and cost

The evolution of the number of MRI exams and their associated reimbursement cost from 2013 to 2016 are presented in Table 5, based on data provided by EOPYY.

Table 5. MRI imaging: analytical data, evolution and comparison of number of exams, installed units and costs reimbursed by EOPYY, 2013–2016 .

Year	No. exams per year					No. units	Average no. exams per unit per year
	Public		Private		Total		
2013	55 471	10%	496 049	90%	551 520	242	2279
2014	59 542	10%	535 316	90%	594 858	249	2389
2015	58 087	9%	557 350	91%	615 437	268	2296
2016	59 546	9%	614 365	91%	673 911	287	2348

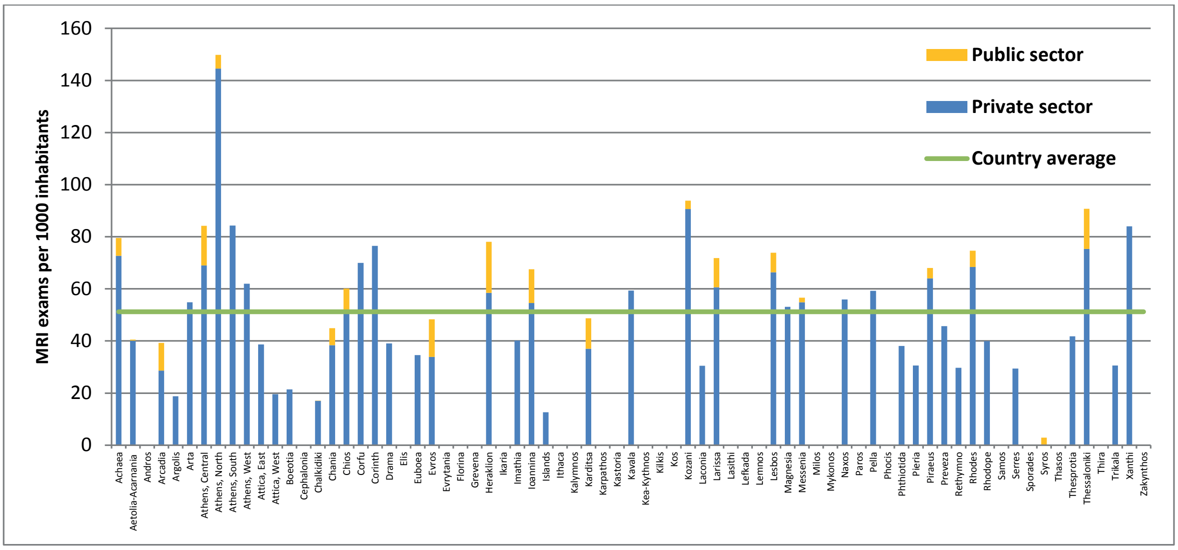
Year	Total EOPYY expenditure per year (€)					EOPYY reimbursement per exam (€)	
	Public		Private		Total	Public	Private
2013	13 069 053	15%	75 531 702	85%	88 600 755	236	152
2014	13 958 605	15%	81 694 905	85%	95 653 510	234	153
2015	13 766 343	14%	85 126 315	86%	98 892 659	237	153
2016	14 053 203	15%	76 843 713	85%	90 896 916	236	125

Source: data from EOPYY.

The use of MRI follows a steadily increasing trend over the four years. The 22% overall increase in the annual number of exams recorded since 2013 is mainly in the private sector, which is dominant in this modality.

In terms of cost, the mean reimbursement from EOPYY is almost 50% lower for the private sector than for the public sector. In 2016, average prices were fixed to €236 per exam in the public sector and €125 EOPYY reimbursement per exam in the private sector. Private-sector reimbursement represents 85% of the total amount of private-sector charges for an MRI scan, the other 15% (approximately €20) is paid by the patient.

Fig. 17. Regional sector distribution of MRI exams per 1000 inhabitants, 2016.

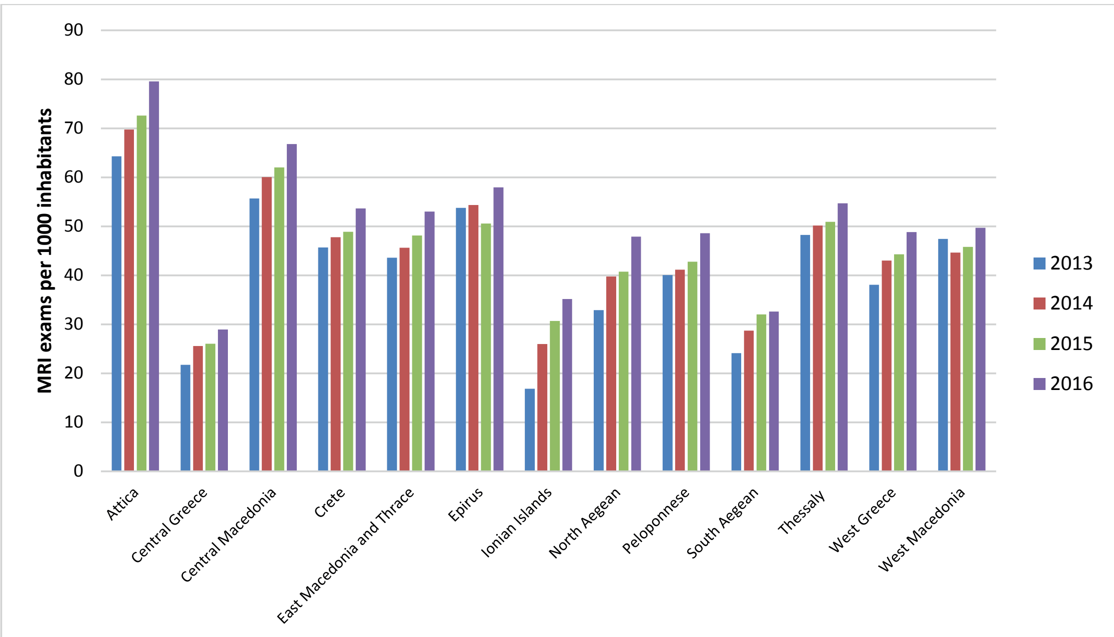


Source: data from EOPYY.

For CT, the highest exam per population ratios are seen in the regions with big cities. This is also expected as they serve not only the inhabitants of the regional sector in which they are installed but also attract and serve some of the population of nearby regions. The market share shown in this graph also indicates that the private sector is covering the vast majority of needs for MRI scans in the country.

As seen in the evolution of the number of MRI scans in the last four years (Fig. 18), the number of exams is increasing. This is in accordance with the fact that MRI scans become faster and less expensive as the technology evolves.

Fig. 18. Time evolution of number of MRI exams per 1000 inhabitants in each administrative region, 2013–2016.



Source: data from EOPYY.

Actual numbers of installed units and number of units per 100 000 inhabitants for CT and MRI units in each Greek regional sector in 2017 are presented in Table 6. All data come from the EEAE website.

Table 6. CT and MRI units: absolute numbers and number of units per 100 000 inhabitants in each regional sector, 2017.

Regional sector	CT		MRI		Regional sector	CT		MRI	
	Absolute number	Units per 100K	Absolute number	Units per 100K		Absolute number	Units per 100K	Absolute number	Units per 100K
Achaea	11	3.6	9	2.9	Kea-Kythnos		0.0		0.0
Aetolia-Acarnania	8	3.8	6	2.8	Kilkis	2	2.5	1	1.2
Andros		0.0		0.0	Kos	1	2.9	2	5.8
Arcadia	4	4.6	7	8.1	Kozani	6	4.0	4	2.7
Argolis	5	5.2	3	3.1	Laconia	2	2.2	1	1.1
Arta	2	2.9	1	1.5	Larissa	11	3.9	10	3.5
Athens Central	51	5.0	33	3.2	Lasithi	4	5.3	1	1.3
Athens North	32	5.4	32	5.4	Lefkada	1	4.2		0.0
Athens South	19	3.6	16	3.0	Lemnos	2	11.6		0.0
Athens West	15	3.1	12	2.5	Lesbos	4	4.6	3	3.5
Attica East	13	2.6	13	2.6	Magnesia	5	2.6	3	1.6
Attica West	5	3.1	3	1.9	Messenia	4	2.5	5	3.1
Boeotia	6	5.1	2	1.7	Milos		0.0		0.0
Cephalonia	2	5.6	1	2.8	Mykonos	2	19.7	1	9.9
Chalkidiki	2	1.9	1	0.9	Naxos	2	9.6	2	9.6
Chania	3	1.9	4	2.6	Paros	1	6.7		0.0
Chios	4	7.6	3	5.7	Pella	6	4.3	5	3.6
Corfu	4	3.8	3	2.9	Phocis	1	2.5		0.0
Corinth	4	2.8	4	2.8	Phthiotida	4	2.5	3	1.9
Drama	4	4.1	2	2.0	Pieria	3	2.4	1	0.8
Elis	4	2.5	2	1.3	Piraeus	25	5.6	11	2.4

Regional sector	CT		MRI		Regional sector	CT		MRI	
	Absolute number	Units per 100K	Absolute number	Units per 100K		Absolute number	Units per 100K	Absolute number	Units per 100K
Euboea	5	2.4	3	1.4	Preveza	2	3.5	2	3.5
Evros	8	5.4	5	3.4	Rethymno	3	3.5	2	2.3
Evrytania	1	5.0		0.0	Rhodes	4	3.3	4	3.3
Florina	1	1.9		0.0	Rhodope	3	2.7	2	1.8
Grevena	2	6.3		0.0	Samos	2	6.1	1	3.0
Heraklion	8	2.6	7	2.3	Serres	3	1.7	2	1.1
Ikaria	1	10.1		0.0	Sporades	1	7.2		0.0
Imathia	4	2.8	1	0.7	Syros	2	9.3	1	4.6
Ioannina	4	2.4	6	3.6	Thasos		0.0		0.0
Islands	3	4.0	1	1.3	Thesprotia	2	4.6	1	2.3
Ithaca		0.0		0.0	Thessaloniki	37	3.3	36	3.2
Kalymnos	3	10.2		0.0	Thira	2	10.6	1	5.3
Karditsa	4	3.5	4	3.5	Tinos		0.0		0.0
Karpathos		0.0		0.0	Trikala	3	2.3	3	2.3
Kastoria	2	4.0	1	2.0	Xanthi	2	1.8	3	2.7
Kavala	3	2.4	3	2.4	Zakynthos	2	4.9	2	4.9
Total						**401**	**3.7**	**301**	**2.8**

Source: data from EEAE.

CT and MRI data analysis and discussion

The positive impact of CTs and MRIs in early diagnosis of serious health diseases and the resulting improvement in the quality of care is widely acknowledged. These two modalities also present a good installation base in Greece. However, only a few new high-end scanners are available: approximately 70% of all CT scanners installed are below 64 slices and 40% are below 16 slices, indicating that 40% of units installed in the country are rather aged. Yet it is important to note that even such obviously old scanners can have diagnostic value when 3D volume imaging is not needed.

As shown by the use and cost data, there are large discrepancies in the number of exams performed per 100 000 inhabitants in the different regional sectors. If regional sectors with big urban areas and cities with university hospitals which provide services to a larger population are disregarded, CT exams range from a ratio of 10 to 145 and MRI exams from five to 95. This could be an indication of overuse as, for instance, examples have been identified of a single CT unit which appears to perform an average of 10 000 exams per year and a single MRI unit performing 6000 exams per year, compared to the mean value of 2700 CT exams per unit and 2350 MRI exams per unit in the rest of the country in 2016. This clearly demonstrates the value of reliable data to investigate potential abuse.

The numbers of CT and MRI units installed in Greece put the country on the top level in Europe. However, a report published by the European Coordination Committee of the Radiological, Electromedical and Healthcare IT Industry (COCIR, 2014) concluded that the installed base of diagnostic imaging equipment in many countries in Europe is becoming older and shows quite pronounced inequalities in access to these technologies. According to COCIR, 60% of the installed equipment base should be less than five years old, 30% should be between six and 10 years old and no more than 10% should be older than 10 years. These figures could be questioned, not only because COCIR represents the industry but also on an evidence-based assessment approach – high-tech devices become outdated more quickly as the lifespan of medical technology shortens and hence may become inadequate to support new medical guidelines and best practices. The COCIR report classifies Greece amongst the European countries with rapid and extensive ageing of CT and MRI equipment: 20% of the installed base for CT is over 15 years old; 25% of the installed base for MRI is over 20 years old. Therefore, although it appears that Greece has a high number of installations, the machines are quite old.

It was not possible to verify these figures due to missing information on the dates of manufacture and when these devices entered into service in Greece. However, taking account of the number of installations, the differences are of the order of 10%. The parallel import of refurbished equipment by the private sector and the absence of strict controls on the technological conformance, age and operational status of these machines, also contribute to this ageing phenomenon.

Diagnostic results depend on image quality and resolution. The use of old machines may therefore have negative consequences and consequently lower the quality of services provided to patients. New equipment – such as the latest 7T MRI scanners recently approved by both the EU and the Food and Drug Administration (FDA) – is now able to distinguish clearly between the white and grey matter of the brain in high detail. They should be installed in some large university hospitals in the near future.

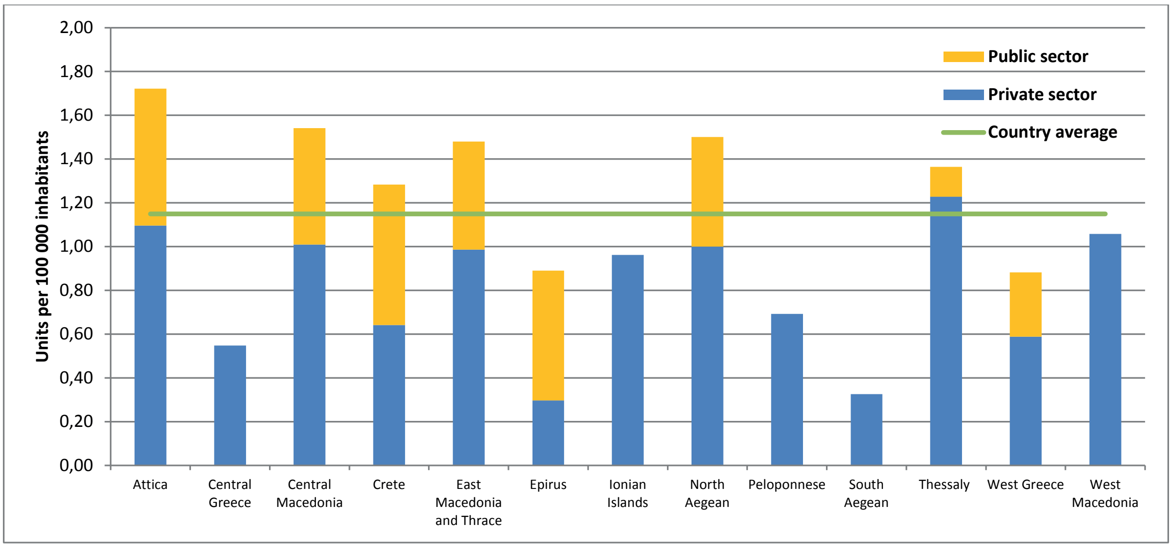
γ-CAMERA/SPECT

Regional distribution

The distribution of γ-camera/SPECT units is much sparser than the modalities already described. Only a few regional sectors have these facilities and so the data are organized and presented by the administrative region in which each unit is installed. A list of the administrative regions and their corresponding populations used to calculate all units per inhabitant ratios can be seen in Table 8. Health regions are not used as Athens and Thessaloniki are each divided into two different health regions (Athens 1st & 2nd and Thessaloniki 3rd & 4th) with vague geographical borders. This makes it almost impossible (or at least easily subject to errors) to define their exact populations and the equipment available, especially for the private sector.

Fig. 19 shows clearly that certain areas (e.g. South Aegean, Central Greece and Peloponnese administrative regions) show marked lacks of γ-camera/SPECT facilities in comparison to other regions and the country's mean value.

Fig. 19. Distribution of γ-camera/SPECT units per 100 000 inhabitants in each administrative region, 2017.



Source: data from EEAE.

For Central Greece in particular, this lack of facilities matches the pattern seen in the number of exams in all the modalities previously described, indicating that health-care coverage in this region lags behind. As already discussed for CTs and MRIs, in many islands of South Aegean the private sector is dominant and the only sector to cover relevant needs in these areas. In the regions of West Macedonia, Ionian Islands, South Aegean, Central Greece and Peloponnese, all the available units are installed in the private sector. Attica and Central Macedonia have the highest number of units installed; this is to be expected since the two biggest cities in Greece (Athens and Thessaloniki) are in these regions.

The analytical data for each region and sector are presented in Table 7.

Table 7. γ-camera/SPECT units: absolute numbers and number of units per 100 000 inhabitants in each administrative region, 2017.

Administrative region	Total units		Private sector		Public sector	
	Absolute no.	Per 100K inhabitants	Absolute no.	Per 100K inhabitants	Absolute no.	Per 100K inhabitants
Attica	66	1.72	42	1.10	24	0.63
Central Greece	3	0.55	3	0.55		0.00
Central Macedonia	29	1.54	19	1.01	10	0.53
Crete	8	1.28	4	0.64	4	0.64
East Macedonia and Thrace	9	1.48	6	0.99	3	0.49
Epirus	3	0.89	1	0.30	2	0.59
Ionian Islands	2	0.96	2	0.96		
North Aegean	3	1.50	2	1.00	1	0.50
Peloponnese	4	0.69	4	0.69		0.00
South Aegean	1	0.33	1	0.33		
Thessaly	10	1.36	9	1.23	1	0.14
West Greece	6	0.88	4	0.59	2	0.29
West Macedonia	3	1.06	3	1.06		
Total	**147**	**1.36**	**100**	**0.92**	**47**	**0.43**

Source: data from EEAE.

The administrative regions and their populations are shown in Table 8. All data are based on the 2011 census.

Table 8. Populations of Greek administrative regions, 2011 census.

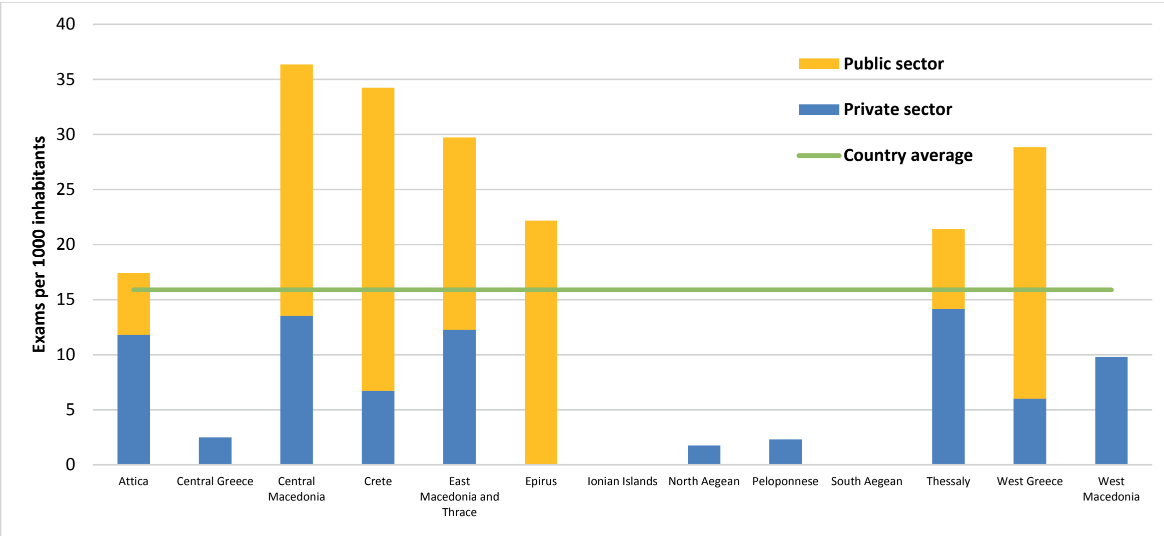
Regions	Population
Attica	3 833 272
Central Greece	547 390

Regions	Population
Central Macedonia	1 882 127
Crete	623 065
East Macedonia and Thrace	608 182
Epirus	336 856
Ionian Islands	207 855
North Aegean	199 929
Peloponnese	577 903
South Aegean	306 644
Thessaly	732 762
West Greece	679 796
West Macedonia	283 689

Use and cost

The number of γ-camera/SPECT exams per 1000 inhabitants is shown in Fig. 20, distributed by administrative sectors.

Fig. 20. γ-camera/SPECT exams per 1000 inhabitants in each administrative region, 2014.



Source: data from EOPYY.

The numbers of exams per administrative region are markedly higher in Central Macedonia, Crete, East Macedonia and Thrace, and West Greece. This can be attributed to the fact that the cities in these regions – Thessaloniki, Alexandroupoli, Heraklion and Patras – are the only cities with γ-camera/SPECT units in their broad areas, and thus cover the needs of populations beyond their own areas.

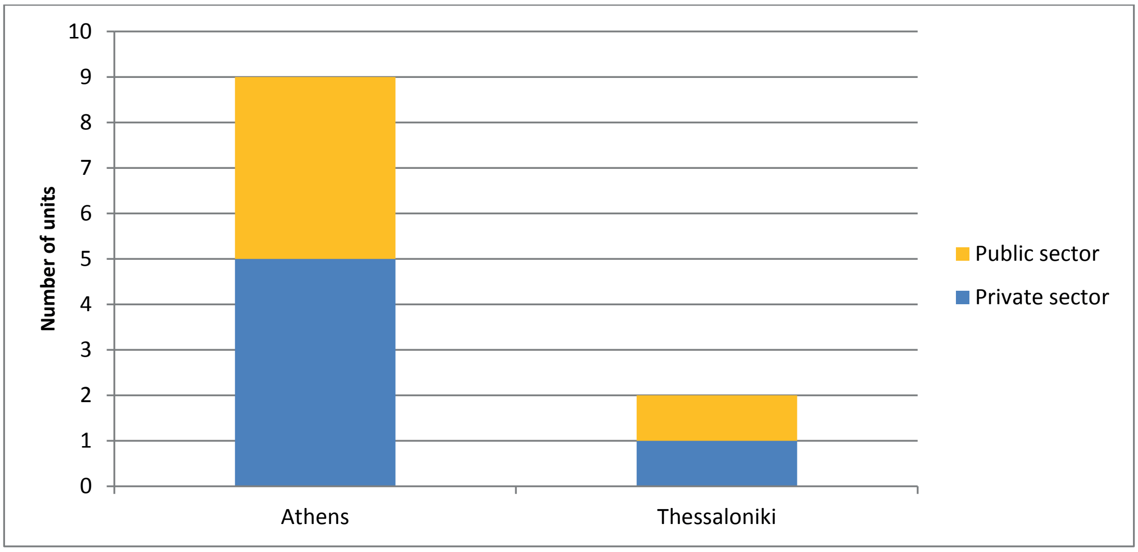
These data are presented in administrative regions since the only data available have been using prefectures (previously Greece's administrative division). Explicit cost data for γ-camera are not available, particularly those concerning the number and type of exams.

PET/CT

Regional distribution

The number of PET/CT units installed is shown in Fig. 21.

Fig. 21. Distribution of PET/CT units in absolute numbers, 2017.



Source: data from EEAE.

It is not surprising that PET/CT units have been installed in only two cities – firstly in Athens and then in Thessaloniki. This is an expensive technique and so the first units were installed in order to cover the largest possible populations, and approximately 40% of the population lives in these two cities. According to the EEAE data, six of 11 units are in the private sector; nine units are installed in Athens and two in Thessaloniki (Table 9).

Table 9. PET/CT units available in private and public sectors, 2017.

City	Private	Public	Total
Athens	5	4	**9**
Thessaloniki	1	1	**2**
Total	**6**	**5**	**11**

Source: data from EEAE.

Use and cost

The evolution of the number of PET exams and the associated reimbursement costs from 2013 to 2016 are presented in Table 10, based on data provided by EOPYY.

Table 10. PET imaging: analytical data, evolution and comparison of number of exams, installed units and costs reimbursed by EOPYY, 2013–2016.

Year	No. exams per year					No. installed units					No. exams per unit per year	
	Public		Private		Total	Public		Private		Total	Public	Private
2013	3 582	69%	1 574	31%	5 156	2	40%	3	60%	5	1 791	525
2014	4 493	63%	2 624	37%	7 117	2	33%	4	67%	6	2 247	656
2015	4 725	53%	4 257	47%	8 982	2	33%	4	67%	6	2 363	1 064
2016	5 542	49%	5 884	51%	11 426	5	45%	6	55%	11	1 108	981

Year	Total EOPYY expenditure per year (€)					EOPYY reimbursement per exam (€)	
	Public		Private		Total	Public	Private
2013	2 352 271	73%	854 318	27%	3 206 589	657	543
2014	2 815 375	66%	1 420 044	34%	4 235 419	627	541
2015	2 875 459	54%	2 427 515	46%	5 302 974	609	570
2016	3 197 965	53%	2 892 737	47%	6 090 702	577	492

Source: data from EOPYY.

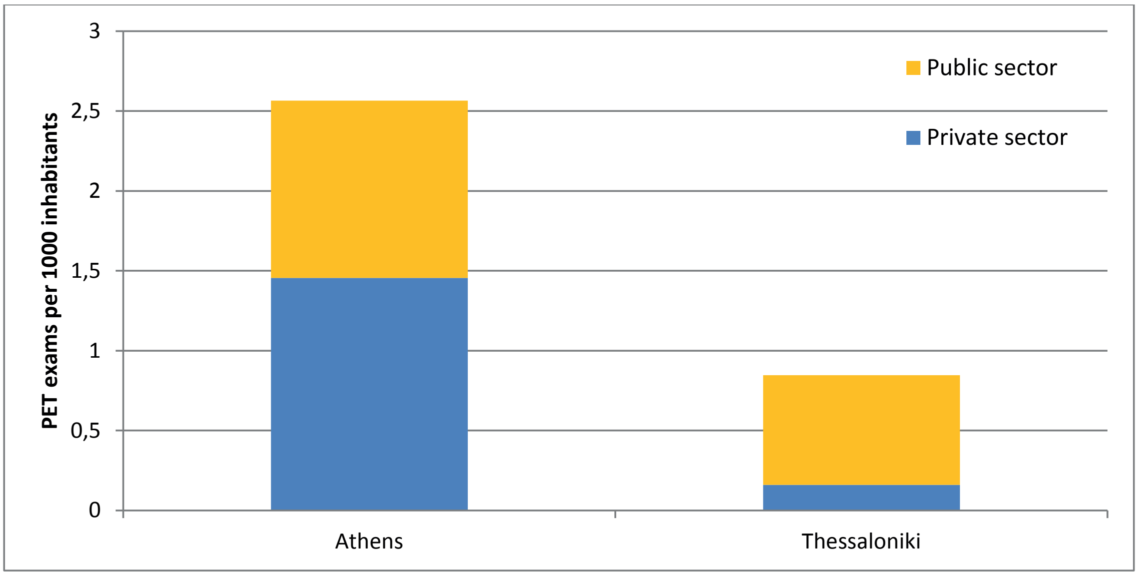
The use of PET is steadily increasing, as expected given that the number of units for this modality recently almost doubled. The number of PET exams performed has increased by approximately 122% since 2013, with the market share in 2016 divided almost evenly between the public and private sector. One possible explanation for the difference in the number of exams per unit between the public and the private sector could be the large out-of-pocket cost. Additionally, in both sectors, not all new units installed during 2016 were in use throughout the year.

The private sector shows a more pronounced increase in the number of installed units – this doubled from three to six between 2013 and 2016, demonstrating that the sector is now investing in the technology.

For EOPYY costs, there is approximately 15% difference between the mean reimbursement for each PET scan – an average price of €577 for the public sector and €492 for the private sector – plus approximately €90 paid by the patient. In both sectors EOPYY reimburses the full cost of the radiopharmaceuticals as invoiced by the provider. It is apparent that the private sector has a higher profit margin in this modality.

The number of PET exams per 1000 inhabitants in Athens and Thessaloniki is shown in Fig. 22.

Fig. 22. Number of PET exams per 1000 inhabitants in cities where scanners are available, 2016.

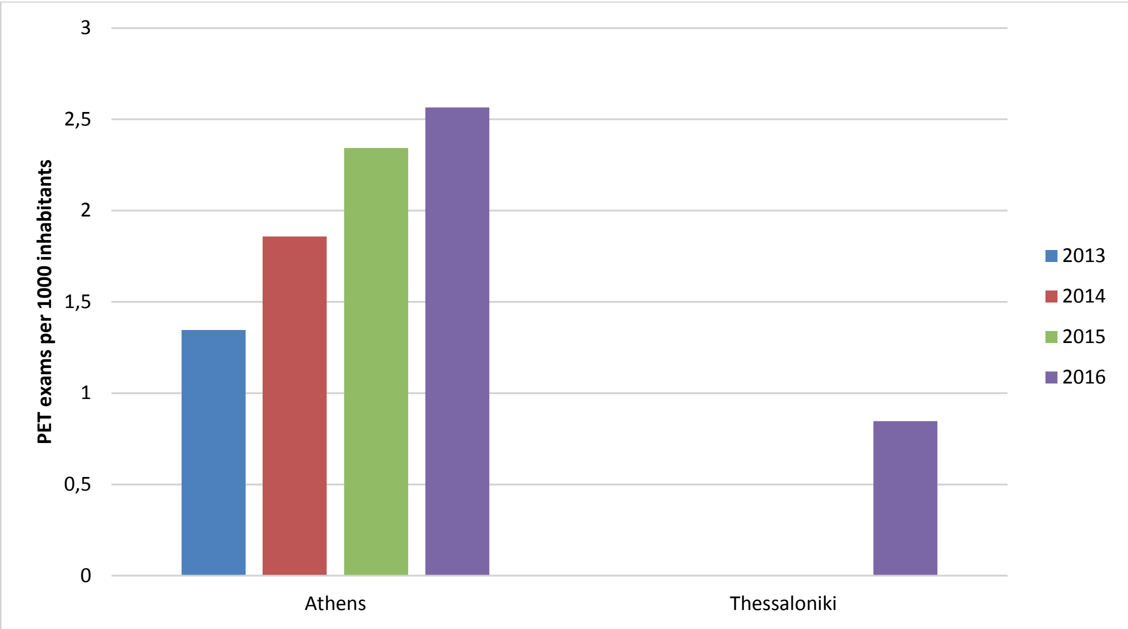


Source: data from EOPYY.

Given that Athens has much higher numbers of scanners than Thessaloniki, the difference in the number of exams is expected. In Thessaloniki there is one scanner in each sector but the inequality in the number of exams is explained by the fact that the scanner in the private sector was installed at the end of 2016.

The evolution of the number of exams per 1000 inhabitants is presented in Fig. 23. This shows a steady increase in the demand in Athens where the technology has been available for longer and therefore the market is more stable. In Thessaloniki, both PET scanners were installed in 2016 and so no time evolution can be seen.

Fig. 23. Time evolution of number of PET exams per 1000 inhabitants in cities where scanners are available, 2013–2016.



Source: data from EOPYY.

Nuclear medicine data analysis and discussion

These modalities are also essential for early diagnosis and monitoring of an expanded range of diseases especially, but not limited to, functional imaging. There are very few γ-camera and SPECT installations in the public sector. The private sector has more installed units covering half of all administrative regions but the public sector is present in only eight.

According to the Hellenic Society of Nuclear Medicine & Molecular Imaging (EEPI&MA), the great imaging value of SPECT/CT technology is underestimated in Greece. This is a powerful tool but only seven units are installed: four in Athens and one each in Patras, Thessaloniki and Ioannina. Only one belongs to the private sector, likely due to the high cost of equipment and the low level of reimbursement from EOPYY.

In comparison to other EU countries, PET installation was delayed in Greece. This was mainly due to a lack of the necessary short-lived positron emitting radioisotopes and radiopharmaceuticals. The situation is now close to the EU average and, due to this delay, the technology installed is quite new. However, prices are relatively high as there is only one supplier of radioisotopes and hence a monopoly. EEPI&MA reports that the cost of radiopharmaceuticals in Greece is amongst the highest in the EU, but the EOPYY reimbursement for these exams is among the lowest. EEPI&MA believes that a second isotope production site is necessary and, in some cases, hospitals should produce their own isotopes.

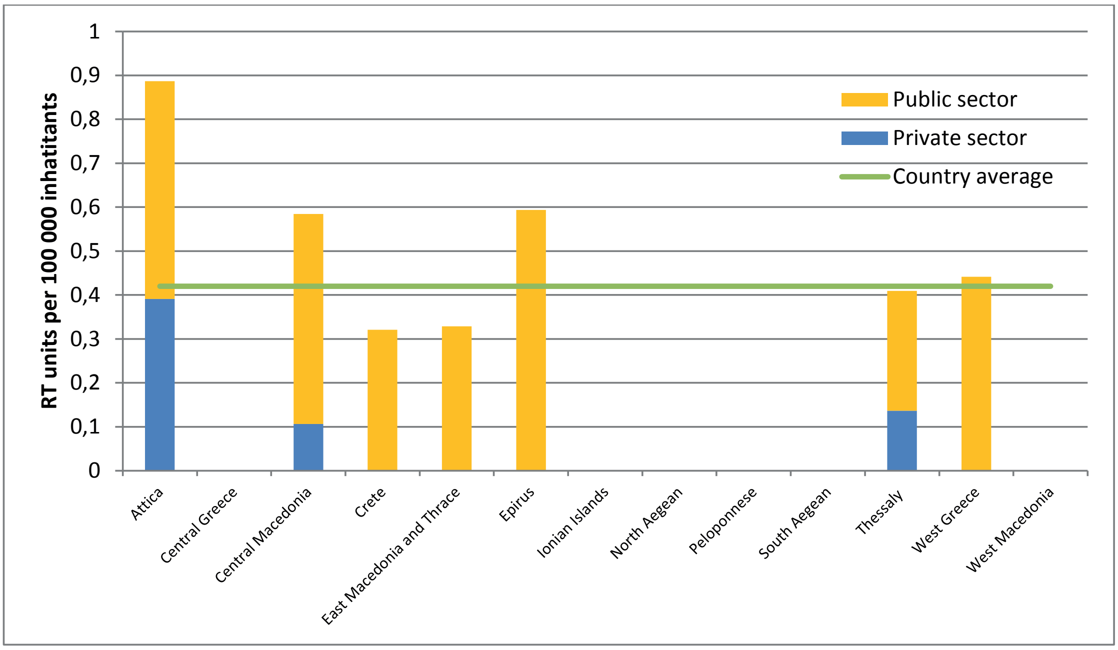
An increase in the number of PET units is expected in the coming years. One PET unit is currently being installed as a donation to the University Hospital of Patras, and three additional units (with baby cyclotrons for radioisotope production) are included in the Stavros Niarchos Foundation's recently announced donation to be installed in public hospitals. Thus, Greece's needs for PET scanners will soon be met, with the public sector retaining leadership in this high-tech medical imaging sector.

RT

Regional distribution

The distribution of RT units is very sparse in comparison with the other modalities already discussed (except PET) and only a few regional sectors have these facilities. For this reason the data are organized and presented for the administrative region in which each unit is installed. The list of administrative regions and their corresponding populations can be seen in Table 8. As for nuclear medicine, health regions are not used because Athens and Thessaloniki are each divided into two different health regions (Athens 1st & 2nd, Thessaloniki 3rd & 4th).

Fig. 24. RT units: distribution per 100 000 inhabitants in each administrative region, 2017.



Source: data from EEAE.

The distribution of RT units in the different administrative regions is shown in Fig. 24. Five of the 13 regions have no RT units – Central Greece, North Aegean, Peloponnese, South Aegean, West Macedonia and Ionian Islands. As for other modalities, Central Greece and South Aegean regions lag behind the other regions. Of the seven regions that have RT units available, only three have units in the private sector. This is expected since RT facilities are very expensive; need both dedicated infrastructures and dedicated specialized human resources; and should be linked to cancer diagnosis and treatment facilities. Conversely, RT units in public hospitals are available in all the other seven regions. Athens (in the region of Attica) has the greatest number of RT units.

With a total of 57 RT units available, resulting in a ratio of 0.53 units per 100 000 inhabitants, Greece meets EU recommendations (Dunscombe et al., 2014). Of these 57 units, 39 are in the public sector and 18 in the private. The exact number and technologies installed in each region are shown in Table 11. It is important to point out that technologies other than LINAC and Co-60 are available only in Athens.

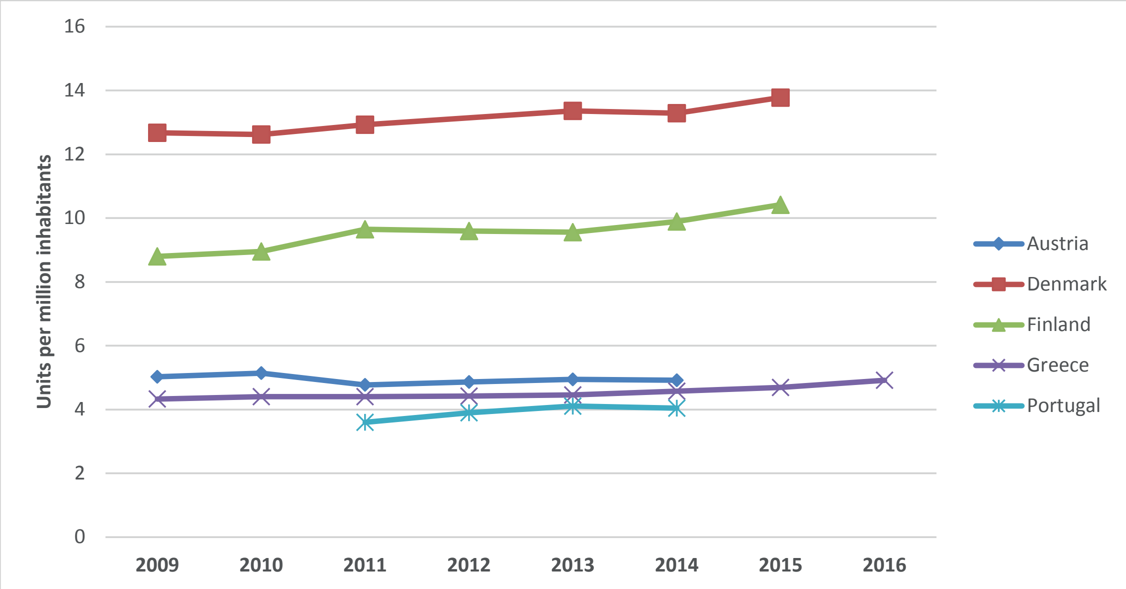
Table 11. RT units: absolute number and number of units per 100 000 inhabitants in each health region, 2017.

Health region	Total RT units		Private sector		Public sector	
	Absolute no.	Per 100K inhabitants	Absolute no.	Per 100K inhabitants	Absolute no.	Per 100K inhabitants
Attica (Athens)	34	0.89	15	0.39	19	0.50
Cyberknife	1	0.03	1	0.03		0.00
LINAC	22	0.57	11	0.29	11	0.29
Co-60	8	0.21			8	0.21
Tomotherapy	2	0.05	2	0.05		
γ knife	1	0.03	1	0.03		
Central Macedonia (Thessaloniki)	11	0.58	2	0.11	9	0.48
LINAC	9	0.48	2	0.11	7	0.37
Co-60	2	0.11			2	0.11
Crete (Heraklion)	2	0.32		0.00	2	0.32
LINAC	2	0.32		0.00	2	0.32
East Macedonia and Thrace (Alexandropolis)	2	0.33		0.00	2	0.33
LINAC	1	0.16		0.00	1	0.16
Co-60	1	0.16		0.00	1	0.16
Epirus (Ioannina)	2	0.59		0.00	2	0.59
LINAC	2	0.59		0.00	2	0.59
Thessaly (Larissa)	3	0.41	1	0.14	2	0.27
LINAC	3	0.41	1	0.14	2	0.27
West Greece (Patras)	3	0.44		0.00	3	0.44
LINAC	3	0.44		0.00	3	0.44
Total	**57**	**0.53**	**18**	**0.17**	**39**	**0.36**

Source: data from EEAE.

Greece meets the recommendations for RT units installed but still has a low ratio of units per 100 000 inhabitants in comparison to Finland and Denmark – their ratios are more than twice as high (Fig. 25).

Fig. 25. Number of RT units per million inhabitants: comparison with four EU countries, 2009–2016.



Source: data from OECD (other EU countries) and EEAE (Greece).

Use and cost

The evolution of the number of reimbursed RT acts and the associated reimbursement costs from 2013 to 2016 are presented in Table 12, based on data provided by EOPYY.

Table 12. RT acts: analytical data, evolution and comparison of number of acts, installed units and costs reimbursed by EOPYY, 2013–2016.

Year	No. reimbursed RT acts per year					No.units
	Public		Private		Total	
2013	232 574	64%	132 986	36%	365 560	49
2014	248 409	61%	160 617	39%	409 026	50
2015	245 393	58%	174 443	42%	419 836	51
2016	233 892	57%	176 549	43%	410 441	53

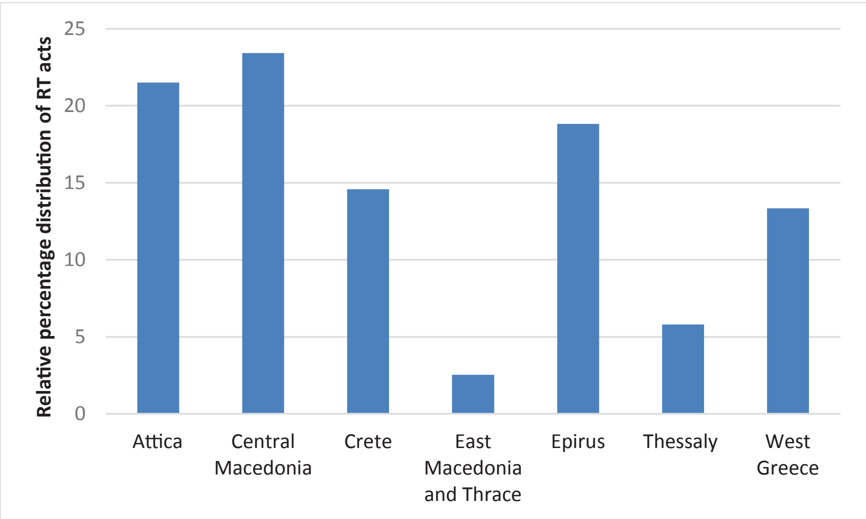
Year	Total EOPYY expenditure per year (€)				
	Public		Private		Total
2013	18 564 495	50%	18 630 985	50%	37 195 480
2014	19 373 735	47%	21 625 454	53%	40 999 189
2015	19 416 459	44%	24 896 716	56%	44 313 175
2016	18 616 010	40%	27 935 467	60%	46 551 477

Source: data from EOPYY.

Despite a few fluctuations, the number of RT acts remains more or less steady between 2013 and 2016. The market share also appears to be almost evenly distributed between the public and the private sector, with a 57:43 ratio.

The relative distribution of RT acts per 1000 inhabitants per administrative region in 2016 is shown in Fig. 26. This graph shows only the regions where RT units are available.

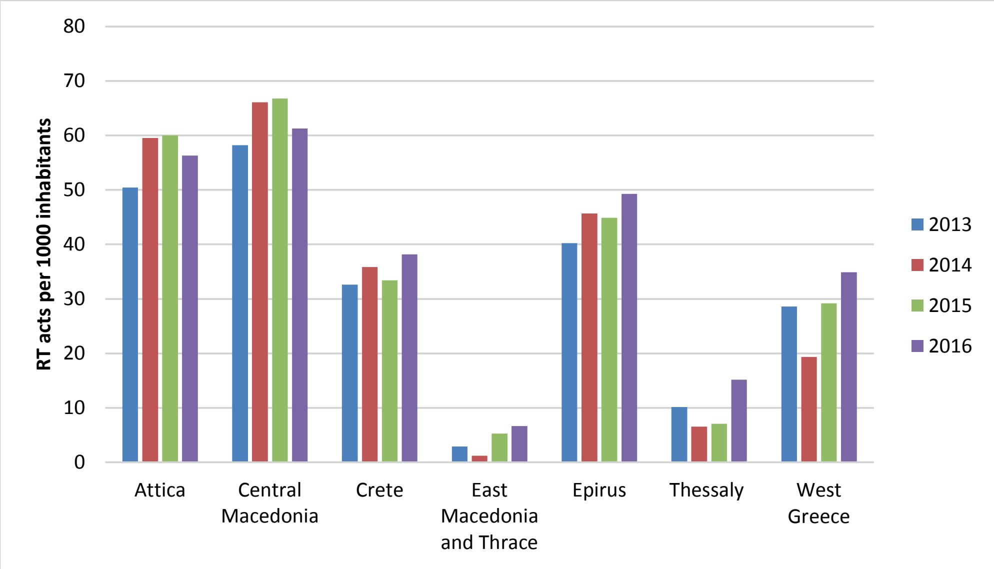
Fig. 26. Relative distribution of RT acts per 1000 inhabitants in each administrative region, 2016.



Note: regions without RT facilities are not shown. ***Source***: data from EOPYY.

Central Macedonia and Attica have the highest percentages of acts because they compensate for the lack of RT facilities in surrounding regions. Some technologies (e.g. γ-knife, cyberknife, tomotherapy) are available only in Athens. The time evolution of the number of RT acts per 1000 inhabitants per region between 2013 and 2016 is shown in Fig. 27.

Fig. 27. Time evolution of number of RT acts per 1000 inhabitants in each administrative region, 2013–2016.



Note: regions without RT facilities are not shown. ***Source***: data from EOPYY.

The number of acts shows an increasing trend in all regions where RT units are available, except for Attica (Athens) and Central Macedonia (Thessaloniki). These two regions show a steady increase from 2013 to 2015 but a slight drop in the number of acts during 2016. This may indicate that fewer patients are moving to these cities from other regions.

Data analysis and discussion

In both private and public health sectors, all RT departments in Greece are licensed according to the national law on radiation protection (EEAE, 2001). In addition, the EEAE closely supervises the terms of radiation protection and compliance with quality and safety regulations for RT treatments. Common practice for the lifetime of treatment machines (8–15 years) does not appear to have changed over the last decade. Until 2016, the vast majority of RT equipment (mainly LINACs and Co-60 units) in the public sector in Greece was more than 15 years old. In 2017, this situation changed radically as a result of the Stavros Niarchos Foundation donating 10 new LINACs to replace old equipment in seven public hospitals.

European directive guidance on the important issues of accessibility and availability of RT equipment (Directorate-General for Energy, 2014) is based on the corresponding European Society for Radiotherapy & Oncology (ESTRO) and European Federation of Organizations for Medical Physics (EFOMP) guidelines. These recommend a ratio of at least one RT equipment available for every 200 000 to 250 000 inhabitants. Given the population of 11.4 million, Greece should have at least 45 to 50 RT machines and therefore it can be concluded that it meets the guidelines on the number of units.

Staff levels in both private and public health sectors fall far below European standards and guidelines. The Hellenic Association of Medical Physicists (HAMP) reports that the New European Directive 2013/59/EURATOM on basic safety standards for protection against the dangers arising from exposure to ionizing radiation, includes a number of articles related to the medical physics profession and competence requirements (articles 14 and 18). It also details the tasks required of experts in medical exposures and radiation protection that are pertinent to the roles and responsibilities of the medical physicist – namely the medical physics expert (MPE) and the radiation protection expert (RPE) (Greek Government, 2017). Like all EU Member States, Greece must transpose this European Directive into national legislation by February 2018.

HAMP identifies under-staffing as one reason why RT is the primary treatment for more than 60% of cancer patients in Europe and the United States, but only 30% of cancer patients in Greece (Atun et al., 2015)”container-title”:”The Lancet. Oncology”,”page”:”1153-1186”,”volume”:”16”,”issue”:”10”,”source”: ”PubMed”,”abstract”:”Radiotherapy is a critical and inseparable component of comprehensive cancer treatment and care. For many of the most common cancers in low-income and middle-income countries, radiotherapy is essential for effective treatment. In high-income countries, radiotherapy is used in more than half of all cases of cancer to cure localised disease, palliate symptoms, and control disease in incurable cancers. Yet, in planning and building treatment capacity for cancer, radiotherapy is frequently the last resource to be considered. Consequently, worldwide access to radiotherapy is unacceptably low. We present a new body of evidence that quantifies the worldwide coverage of radiotherapy services by country. We show the shortfall in access to radiotherapy by country and globally for 2015-35 based on current and projected need, and show substantial health and economic benefits to investing in radiotherapy. The cost of scaling up radiotherapy in the nominal model in 2015-35 is US$26·6 billion in low-income countries, $62·6 billion in lower-middle-income countries, and $94·8 billion in upper-middle-income countries, which amounts to $184·0 billion across all low-income and middle-income countries. In the efficiency model the costs were lower: $14·1 billion in low-income, $33·3 billion in lower-middle-income, and $49·4 billion in upper-middle-income countries-a total of $96·8 billion. Scale-up of radiotherapy capacity in 2015-35 from current levels could lead to saving of 26·9 million life-years in low-income and middle-income countries over the lifetime of the patients who received treatment. The economic benefits of investment in radiotherapy are very substantial. Using the nominal cost model could produce a net benefit of $278·1 billion in 2015-35 ($265·2 million in low-income countries, $38·5 billion in lower-middle-income countries, and $239·3 billion in upper-middle-income countries. As a result the Greek health system in Greece is forced to pay for less effective and more expensive treatments such as surgery and extensive chemotherapy.

A structural problem should also be mentioned. The fact that most centres have only one or two RT machines results in high overhead costs for the accompanying equipment. At the same time, the wide spread of equipment critically affects a patient’s treatment. Currently, 28 LINACs are installed in 15 public sector RT departments in seven large Greek cities. Of these, four have only one unit, 10 have two units and only one has three units. In cities with other public RT departments, single unit RT departments are ineffective in both organization and service provided. Reorganization into bigger RT centres could produce serious resource savings and improvements in the treatment provided.

General issues

Medical devices are now used in virtually every health-care delivery process. Yet their diversity is matched by the range and complexity of problems that can arise from their use. These include mechanical failure, faulty design, poor manufacturing quality, adverse effects of materials implanted in the body, improper maintenance/specifications and user error. Whether used for diagnosis or therapy, a health-care facility should ensure that the equipment is performing as intended by the manufacturer. Additionally, the uncontrolled use of technology in medicine can result in increased costs for delivery of health-care services. Hence, it has become evident that there is a need to develop a proper infrastructure for evaluating, supporting and managing biomedical technology. Greece lacks reliable information related to medical devices, including the technologies addressed in this study. The following sections outline some general facts and comments, not only on this issue but also on maintenance and staffing.

REGIONAL DISTRIBUTION

As presented in Annex 3, four regional sectors (Ithaca, Kea-Kythnos, Thasos, Tinos) have none of the investigated HVCE modalities. Of the other regional sectors, three have only MUs and another 10 have both MUs and CT scanners. All three modalities (mammograms, CT, MRI) are available in only 22 of the 74 regional sectors.

Further analysis of the distribution of the three most common modalities shows that MUs are absent in four regional sectors. This lack is covered with mobile MUs operated by the Hellenic Cancer Society. Only private sector MUs are available in 14 regional sectors; only public sector MUs are available in three. Both sectors provide this modality in all the other regional sectors. CT scanners are not available in seven regional sectors. Only private sector CT scanners are available in nine regional sectors; only public sector CT scanners are available in five. Both sectors provide this modality in the other 53 regional sectors. MRI units are not available in 17 regional sectors. Only private sector MRI units are available in 37 regional sectors; both sectors provide this modality in 20 regional sectors.

For nuclear and RT facilities: γ-camera/SPECT units are available in 35 regional sectors; RT is available in 10; and PET is available in only four, in the two major cities of Greece (Athens and Thessaloniki). PET and RT are available only in large urban areas and the public sector has very good presence in these two modalities, especially in RT where it is clearly ahead of the private sector. While 39 regional sectors have no units available, the private sector alone provides γ-camera/SPECT facilities in 23 of the other regional sectors and both public and private sector coverage is available in only 12 regional sectors.

In conclusion, the following four important observations can be made.

1. Four regional sectors do not have the investigated HVCE modalities – Ithaca, Kea-Kythnos, Thasos, Tinos.
2. Three regional sectors have only MUs and no MRI or CT scanners – Andros, Karpathos, Milos.
3. Four of the 22 regional sectors with only three modalities (MU, CT, MRI) have these modalities available only in the private sector – Kos, Mykonos, Preveza, Thira.
4. Six regional sectors have CT and MRI available only in the private sector – Arta, Kos, Mykonos, Naxos, Preveza, Thira.

STRATEGIC PLANNING OF INVESTMENTS IN HVCE

Strategic planning for HVCE is essential for better coverage of needs, through prioritizing actions for the best use of available resources. The most important step in this procedure is needs assessment for medical devices, at all levels of the health-care sector. This issue is addressed in detail in *Needs assessment for medical devices*, published by WHO within its medical device technical series (WHO, 2011). In brief, this proposes a seven-step procedure – five related to baseline information on health service requirement, health service availability, medical devices, human resources and finances. The sixth is dedicated to analysis and interpretation and the seventh to prioritization, appraisal of options and implementation. Following this procedure enables evidence-based prioritization of needs and final decisions, with a clear emphasis on the importance of information and data.

The implementation phase is also very important for specifying the technology requirements in accordance with actual needs. One of the most critical parameters is preparation of the functional and technical specifications, as well as the terms and conditions for warranty, maintenance and user training. For HVCE, the group of technologies addressed here, this task should primarily be fulfilled centrally in order to guarantee the best outcomes in terms of quality and costs. Installation issues should also not be neglected and acceptance testing is essential for quality and safety prior to entry into service and use.

In general, strategic investment planning, correct maintenance and management of medical technology should become a priority. Control in high-tech and value capital – in terms of equipment acquisition, distribution, performance, maintenance procedures and safety – are essential and should be reorganized.

LACK OF RELIABLE DATA

Data on purchase price, annual maintenance costs, downtime and actual use of devices are lacking. Evidence-based decisions are impossible without adequate data and information and it is impossible to calculate the median age of the installed bases, their value, annual service costs and annual use; or to estimate potential underuse of the machines or calculate incremental costs of corrective actions. During the last three decades, computerized maintenance management systems (CMMSs) for medical equipment have been used worldwide, providing all necessary data for cost-effective management and evidence-based decisions.

Another information issue arises from the parallel import of refurbished equipment by third parties. This concerns mainly the private sector and, although its extent could not be estimated in numbers, contributes to the ageing problem as these devices are already more than five years old when they start to be used in Greece. At the same time, apart from EEAE control and licensing, there is no clear procedure to certify that these devices continue to comply with the EU 2017/75 regulation requirement that they function as intended by the manufacturer.

MAINTENANCE

Aggregated data on maintenance costs of HVCE in the public sector are not available. Most hospitals have maintenance contracts with equipment providers but these are negotiated on a case-by-case basis and the actual costs are not known. As a general rough estimate, the assumption of an annual cost of 8% to 10% of the initial equipment purchase price could be used. Maintenance and repair issues are becoming more critical as the equipment ages. After the initial three- to five-year period during which maintenance is usually well-defined in the procurement agreement, in many cases price negotiations are under the control of manufacturers.

It is necessary to apply modern computerized tools for medical equipment management (e.g. CMMSs which include functional inventories). These have been available since the late 1980s but installed in just a few Greek hospitals. Such systems have multiple advantages, providing a complete and updated inventory at any time, with at least the following essential information for each machine – make and model, value, annual maintenance costs, weekly operating hours and number of uses. Such a system would have made the data collected within this study available instantly to the Ministry of Health, avoiding a great deal of effort and enabling verification. Additionally, such systems are essential for vigilance purposes, evidence-based decisions on replacement, and control of service providers (i.e. response time, cost, respect of service contract rules) amongst many others.

STAFFING

Modern health-care delivery is undoubtedly based on a team approach and a number of professionals other than medical doctors are involved in most cases. Medical physicists, radiographers and other technologists; nurses; and biomedical/clinical engineers are directly involved in everyday activities. Departments providing diagnostic imaging and RT services require adequate and balanced staffing. Additionally, rapid technological developments lead to the high-paced introduction of new or improved devices, and require lifelong learning and continuous training for all these professionals. Health-care systems should provide the necessary means and facilitating conditions to guarantee the level of knowledge and skills of staff through certification procedures.

Professional associations should play an important role in such procedures, and assessment should become a priority for all. It is very important to convince staff members that the whole procedure aims to improve quality and safety and provide better diagnosis and treatment for patients.

Conclusions and recommendations

GENERAL CONCLUSIONS

Uneven geographical distribution of HVCE is a problem in many EU countries, resulting in inequalities in access for people living in rural and remote areas. With tens of islands and mountainous areas that are difficult to access, health-care delivery is a major concern in Greece. According to the findings on the medical equipment categories covered in this study, the installed base in Greece is above the European average. However, apart from mammography, these technologies are installed mostly in large urban areas. The private sector is more present than the public and the only provider of CT and MRI diagnostic imaging services in some smaller cities in central Greece and some islands. Coverage is particularly poor in the Aegean Sea islands and most lack modern diagnostic imaging equipment. RT is available in only seven big cities and is the only modality in which the public sector is dominant. PET is available only in Athens and Thessaloniki.

Lack of a continuously updated inventory means that there are no centrally available data concerning medical equipment in general or for information on the maintenance, age and actual use of devices. Although well-structured and publicly available, the EEAE database on medical radiation installations provides information related to radiation safety and licensing purposes. This lack of information prevents calculation of critical indicators (e.g. median age of installed equipment) in the context of this report. Estimations based on other sources indicate that the average age of these machines is higher than the optimum in most cases. Maintenance cost information in the public sector is not available but appears quite high since it can range from 5% to 12% of the equipment purchase price. Sources of reliable information are generally needed in order to estimate potential underuse, identify unjustifiably high management costs or calculate incremental costs of corrective actions. Evidence-based decisions are impossible without adequate data and information.

For details of use and costs issues related to these technologies, EOPYY uses a quite comprehensive information system that provides reliable data on acts performed and associated payments. However, this represents only the part of the acts reimbursed by the organization. Those covered out-of-pocket or by private insurance remain unknown. EOPYY data indicate that diagnostic means are overused in some areas but underused in others, even when the technology is available. Generally, prescription of diagnostic tests is still not based on clinical guidelines and best practices. This leaves room for overprescription; unnecessary exams (with associated costs and burden); and potential harm to patients.

When calculating reimbursement costs, EOPYY does not differentiate sufficiently the technological status of the equipment used in the diagnostic exams. This encourages the private sector to continue to use machines that are older or of lower performance. This is also reflected in the parallel import of refurbished equipment by the private sector. The fact that there is no strict control of the technological conformance, age and operational status of this equipment may lower the quality of services rendered to patients.

Staffing is also considered to be a problem in many cases. Particularly in RT departments, there is a discrepancy between the actual number of staff employed (especially non-medical) and the number recommended by (already approved) EU guidelines. Additionally, there are no systems for continuous training and lifelong learning and no monitoring and evaluation schemes for staff competences, where appropriate.

Finally, strategic planning for investments in new HVCE it is not well-defined and decision-making is neither evidence based nor transparent in the public sector. The private sector follows its own approaches, based on market analysis and assuming a stable state policy, which is not the case in the period covered by this study.

RECOMMENDATIONS

This report covers only some high value capital medical equipment but the following recommendations apply not only to all technologies of this category but also to those related to broader medical equipment. Improvement of HVCE investment planning is a critical factor for ensuring that health-care systems are more cost effective and able to respond to patient needs in the most efficient way. Therefore, HVCE should be installed and used according to well-defined criteria, needs assessment analysis and priority settings at all levels of the national health system. Greece should develop its health technology assessment (HTA) capacity, as suggested by a 2016 WHO mission on HTA in Greece. This should include medical devices as rapid assessment and hospital based HTAs are very powerful tools for decision-making on this type of technology. It is recommended that a working group on HTA for medical devices should be established within the framework of the HTA mechanisms to be put in place by the end of 2017. This should aim at: facilitating information exchange and enhancing collaboration between stakeholders with an interest in medical device HTA; organizing translation or commissioning adaptations of existing HTA reports to the Greek context; and creating and maintaining a database of relevant reports.

Evidence-based decisions for HVCE procurement in the public sector should be promoted at all levels. Involvement of scientific/professional societies and other stakeholders should be encouraged in an open dialogue procedure. Technical specifications should be provided centrally; cover various needs, depending on the size and nature of the hospital; and be updated. Rules and restrictions on parallel import of refurbished equipment should be established.

The availability of reliable data on the technology installed is absolutely necessary for correct decisions on technology procurement, management and replacement. A well-structured medical equipment inventory is essential to ensure an immediately available, clear and updated picture of the technology in use, in both public and private sectors. Reimbursement to all hospitals, clinics or diagnostic centres should be dependent on submission of a basic data set of information (including equipment make and model, value, age, technology status) for their entire HVCE installed base. A decision on an international nomenclature system, which should comply with the new EU regulation of medical devices, is expected to be taken by 2020. This nomenclature system should be enforced and translated in Greece and is also essential for medical device vigilance.

New medical device regulations (MDRs) replacing the medical device directives (MDDs) were adopted on 5 April 2017. They entered into force via a three-year transitional period starting on 25 May 2017 (EU 2017/745) and will come into full force in 2020. In order to assure a smooth transfer from the directives to the regulation, the authorities must undertake a number of critical actions during the transition period. These will include improvement of transparency and traceability for medical devices based on the Unique Device Identification system; reinforcement of the rules on clinical evidence, including an EU-wide coordinated procedure for authorization of multi-centre clinical investigations; strengthening of post-market surveillance requirements for manufacturers; and improvement of vigilance and market surveillance mechanisms in EU countries. A detailed action plan should be prepared (if not already done) and the necessary actions carefully implemented to be ready to work within this new regulatory environment.

The absence of biomedical/clinical engineering departments in most Greek hospitals is a great obstacle to effective and safe management of medical technology, resulting in incomplete records and no quality and cost control. Maintenance of HVCE and the relevant costs should be followed using modern computerized systems in all public-sector hospitals. Such systems are available but used in only a very limited number of public hospitals even though they are essential for the overall management of medical equipment in use. Maintenance services should also be regulated in terms of technicians' experience, skills and certification required to perform these tasks. External service providers should employ certified and adequately trained technicians for whom they should be accountable.

Adoption and use of international best practices and clinical guidelines should be regulated in collaboration with the relevant medical societies. Apart from the direct benefits for patients, this would also reduce the induced demand for unjustified prescriptions and the related costs. The private sector should make available the relevant data on exams that are not reimbursed by EOPYY in order that health authorities have a complete picture of the diagnostic and therapeutic acts performed and not registered elsewhere.

Staffing of departments that use HVCE should also be regulated in line with best practices and guidelines, and in accordance with EU regulations and directives. Application of these regulations should become a priority and personnel numbers in these departments should be based on the HVCE installed rather than the number of beds. Adequate staffing could allow the available infrastructure and equipment in Greece to be fully exploited, resulting in economy of resources and better patient treatment. Continuing professional development (CPD) should also be organized in collaboration with professional societies to assist personnel in keeping pace with recent technological developments. Given the tremendous progress in medical imaging, the establishment of subspecialties in radiology should be examined in order to take full benefit of the potential offered.

Finally, all actions and initiatives towards the implementation of such recommendations should be well-designed; based on correct baseline data concerning existing needs, population, infrastructure and availability of human resources; and accepted to the largest possible extent through consensus building approaches with users and stakeholders. Clinical guidelines, best practices and safety issues should be also taken into account during the analysis for prioritization of needs.

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Annex 1. Meetings with professional bodies

A number of meetings were arranged with the following professional bodies of stakeholders in the field: Hellenic Association of Medical Physicists (HAMP), Hellenic Society of Biomedical Technology (ELEVIT), Federation of Technologists Radiologists of Greece (OTAE), Hellenic Society of Nuclear Medicine & Molecular Imaging (EEPI&MA), Association of Health–Research & Biotechnology Industry (SEIV) and the Hellenic Radiological Society (HelRAD).

At the time, it was not possible to hold a meeting with the Hellenic Society for Radiation Oncology (EEAO). The Pan-Hellenic Association of Medical Diagnostic Centres (PASIDIK) replied that there is no interest in participating in such a meeting.

All the meetings held were extremely interesting and provided valuable input for this report. Minutes of the meetings are provided in the following pages.

FEDERATION OF TECHNOLOGISTS RADIOLOGISTS OF GREECE (OTAE)

The meeting with OTAE took place on 31 August 2017 at the WHO offices in the premises of the Greek Ministry of Health.

Present on behalf of OTAE: Mr Konstantinos Georgiadis, President of OTAE; Mr Spiros Droulias, General secretary; Mr Lefteris Sigalos, member of the board.

Present on behalf of WHO/Institute of Biomedical Technology (INBIT): Athanasios Myloneros, WHO National Professional Officer; Professor Nicolas Pallikarakis, INBIT President of the board; Dr Aris Dermitzakis, Biomedical engineer.

After a short presentation on the objectives and aims of this study, the OTAE representatives outlined the role of the federation since 2009 – as the only secondary professional institutional instrument representing its members that possess statutory occupational rights (Presidential Decree 164/1996) and corresponding licensure (Presidential Decree160/2014) to daily apply the practical aspects of treatment in both public and private health-care structures. Radiology radiotherapy technologists are health-care professionals exclusively assigned (Presidential Decree 198/2007) to use imaging radiotherapeutic and nuclear medicine units. The meeting concluded with a presentation and extensive discussion of the sources of information and data collected so far.

Main outcomes and issues arising from this meeting

The available infrastructure and equipment in Greece is not exploited to its full capacity. Understaffing is the main reason for this – departments have too few radiographers even though there are more than enough trained individuals available in Greece to cover all the needs of the health system. Another factor is the working hours split between the health professionals involved and the lack of a second shift in almost all facilities. One very important issue is that personnel without adequate training are used to cover gaps in understaffed hospitals. Also, even qualified personnel now employed do not receive proper lifelong education and continuous training to meet current developments and needs to enable all the capabilities of new technologies to be exploited.

As far as the understaffing is concerned, the OTAE representatives pointed out that European Commission guidelines require two technologists per shift to be present for every CT facility and three per shift for every LINAC facility. In Greece, personnel levels in the respective departments are based on the number of beds available in each hospital, and not the radiological equipment installed. Another very important issue raised is the considerable amount of installed equipment in Greece that is used for medical purposes without the necessary licence from EEAE. The related inventory prepared by OTAE in 2016 was made available to WHO/INBIT for the purposes of this report and was used to crosscheck EEAE data.

OTAE STATEMENT: *The Federation of Technologists Radiologists of Greece (OTAE) is the only secondary professional-scientific body representing radiology/radiotherapy technologist (radiographer) professionals, exclusively assigned (Presidential Decree 198/2007) to use imaging, radiotherapeutic and nuclear medicine devices in Greek health-care institutions. Its members possess statutory occupational rights and corresponding licensure to daily apply the practical aspects of medical exposure imaging and treatment equipment, in public and private health-care institutions. The productive and qualitative deployment of ionizing and non-ionizing HVCE is highly dependent on the number, dispersion and competences of the professional users. Taking into account the data presented on CTs, MRIs, PET, LINAC etc, the biggest issue observed is the lack of such specialized staff. In the public sector, the number of radiology radiotherapy technologists is not based on the medical infrastructures available in the hospitals, but on the number of beds of each hospital. OTAE is closely monitoring the commissioning of high-tech medical systems and – having identified problems in its distribution, false criteria during acquisition and errors of use – strongly believes that it is vital to establish a legal framework, linking the installed base of the above systems with the required number of radiology radiotherapy technologists specialists (radiographers), in order to ensure productive and qualitative function of imaging, radiotherapeutic and nuclear medicine technology.*

HELLENIC SOCIETY OF BIOMEDICAL TECHNOLOGY (ELEVIT)

The meeting with ELEVIT took place on 31 August 2017 at the WHO offices in the premises of the Greek Ministry of Health.

Present on behalf of ELEVIT: Mr Vasileios Gkergkis, Vice president.

Present on behalf of WHO/INBIT: Professor Nicolas Pallikarakis, INBIT President of the board; Dr Aris Dermitzakis, Biomedical engineer.

The meeting began with a presentation of the objectives and aims of this study, as well as the sources of information and the data collected so far. ELEVIT identified the main reasons for the problems facing the Greek health system: unorganized growth without any central action plan; procurement procedures that do not consider real needs and the maintenance and operation costs for a time period of 10 years, the expected lifespan of the equipment. Additionally, equipment downtime is neither taken into account nor monitored.

Specifications should be created centrally by a dedicated working group, and should be multilevel, covering needs according to the size and nature of the hospital. Specifications should be updated annually.

As currently managed, equipment donations do not provide full benefit to the health system. Four main questions should be considered: (i) who is making the donation? (ii) is the person connected with the hospital? (iii) is the equipment suitable for the hospital? and (iv) are maintenance costs included?

Technology management is not well-organized, with no use of computerized medical equipment management systems (CMMSs), resulting in incomplete records and no control of service. Services provided by third parties were raised as a critical issue in Greece since medical equipment can be maintained by anyone who has verification of experience, and not certification. ELEVIT proposes that each company should provide a list of certified and trained technicians for whom they will be accountable.

ELEVIT STATEMENT: *Created in 1972, the Hellenic Society of Biomedical Technology is continuing to follow the developments in medical technology that have revolutionized modern health-care delivery over the past 60 years. The society has been very active in organizing various scientific events at both national and international level, involving its members in R&D, continuous education and training activities. ELEVIT stresses the lack of biomedical engineers as distinct, officially recognised professionals/specialists in the Greek health-care sector. The absence of biomedical/clinical engineering departments in most Greek hospitals is a great obstacle to effective and safe management of medical technology. Strategic investment planning, correct maintenance and management of medical technology should become a priority. Control in high-tech and value capital – in terms of equipment acquisition, distribution, performance, maintenance procedures and safety – are essential and should be reorganized.*

HELLENIC SOCIETY OF NUCLEAR MEDICINE & MOLECULAR IMAGING (EEPI&MA)

The meeting with EEPI&MA took place on 31 August 2017 at the WHO offices in the premises of the Greek Ministry of Health.

Present on behalf of EEPI&MA: MD Koytsikos Ioannis, General secretary of EEPI&MA; and MD Prasopoulos Vasilis, Treasurer.

Present on behalf of WHO/INBIT: Professor Nicolas Pallikarakis, INBIT President of the board; Dr Aris Dermitzakis, Biomedical engineer.

After a short introduction on the objectives and aims of this study, INBIT presented the sources of information and data collected so far. According to EEPI&MA, nuclear medicine equipment (γ-cameras) in Greece is old, which influences the quality of health services supplied. It was stressed that the Greek Atomic Energy Commission (EEAE) has probably the best database on all equipment involving ionizing radiation installed in Greece. For the number of diagnostic and therapeutic acts related to the technologies in question, they estimate that EOPYY's data, based only on those reimbursed by the organization, represent about 60% of the total number of acts performed in Greece. This is because acts paid directly by patients, by private insurance or at military hospitals are not included. The issue of induced demand should be subject to more direct state control. Underuse of the great imaging value of SPECT/CT was also stressed – only one SPECT/CT is available and only in the private sector.

Although the number of PET scanners is currently lower than the European average, needs will be met by the new installations in Heraklion, Patras and Alexandroupolis. The great issue at present arises from there being only one supplier of nuclear isotopes, and thus a monopoly. For Greece, this leads to isotopes being amongst the most expensive in the EU, while at the same time EOPYY's reimbursement of exams is among the lowest. The number of cyclotrons used in isotope production should be increased and in some cases isotopes should be produced within the hospitals.

Nuclear medicine departments are understaffed even though sufficient numbers of the trained personnel required are available in Greece. It is suggested that each department should obtain EANM Research Ltd (EARL) certification.

EEPI&MA STATEMENT: *Hellenic Society of Nuclear Medicine and Molecular Imaging (EEPI&MI) is one of the oldest European societies in nuclear medicine (founded in 1968) and its membership now numbers approximately 400 colleagues.*

Taking account of the data presented in this report, we have to mention that, unlike other imaging applications, nuclear medicine examinations have not burdened the cost of health care during recent years as we have not noticed an increase in nuclear medicine examinations (evolving demand).

Furthermore, we have to mention that the nuclear medicine equipment (γ-cameras) in Greece is old, influencing the quality of health services supplied. Conversely, so-called sub-costing of our medical exams removes the ability to depreciate new equipment. However, the Greek government has to invest in new hybrid technologies and especially in SPECT/CT, which is particularly underused – only one SPECT/CT in Athens is available in the private sector and the number of PET/CT units per million inhabitants is the lowest between 10 EU countries.

Finally, a crucial problem that has to be solved in the near future is understaffing in the nuclear medicine departments (particularly in public hospitals).

HELLENIC ASSOCIATION OF MEDICAL PHYSICISTS (HAMP)

The meeting with HAMP took place on 5 September 2017 at the WHO offices in the premises of the Greek Ministry of Health.

Present on behalf of HAMP: Dr Virginia Tsapaki, President; Dr Pola Platoni, Secretary general; Professor Kiriaki Theodorou, Professor of medical physics.

Present on behalf of WHO/INBIT: Professor Nicolas Pallikarakis, INBIT President of the board.

A short introduction on the objectives and aims of this study was followed by extensive discussion of issues concerning the number of installed units, quality control, radiation protection and the role of medical physicists. The HAMP representatives offered to prepare a report in order to assist the completeness of the present report. A high-quality HAMP input was prepared and delivered at a second stage and widely used for the purposes of this study. The main points are used in the report and outlined in the following paragraphs.

Until 2016, the vast majority of radiotherapy equipment (mainly LINAC and Co-60 units) in the public sector was more than 15 years old. As a result, cancer patients could not be offered any modern and effective radiotherapy techniques, namely – intensity modulated radiation therapy with image guidance (IMRT/IGRT). Whereas the mean turnover of these types of equipment is seven to eight years in Europe and the United States of America, the corresponding time in Greece is over 16 years in the public health sector and over 10 years in the private sector.

One other consideration is servicing of this equipment. In the private sector, all machines are covered by service contracts for both maintenance and repair (usually the repair process is within 24 hours). In the public sector, most radiotherapy departments also have service contracts, but administrative reasons cause long delays in maintenance and thus increase the total down time of this equipment.

Finally, staffing levels of medical physicists are far below the European standards and guidelines for safety in both private and public health sectors. This is reducing the quality and safety of treatments.

Data on imaging equipment in the public sector show that, of the seven health regions in Greece, the fourth (Macedonia and Thrace) has a significant lack of γ-camera while MRIs and γ-cameras are less commonly available in the fifth health region (Thessaly and Central Greece). The low availability per population ratio in these health regions might be compensated by equipment in the private sector. It is also considered that imaging equipment needs a significant amount of upgrading or replacing. In addition, the distribution of new equipment should be assessed according to the capacity and capabilities of each hospital.

HAMP STATEMENT: *Over the past 30 years, the Hellenic Association of Medical Physicists has been closely monitoring the status of radiological diagnostic and therapeutic equipment throughout the country. Quality assurance/quality control procedures are applied to clinical practices as well as the development of its own members in terms of professional status and education and training. Taking account of the data presented in this report, one of the major problems is staffing levels, as far as medical physicists* *are concerned. The shortage of qualified medical physicist experts in current diagnostic and therapeutic radiological procedures is actually damaging the quality and safety of the health services provided and has to be solved in the near future. Furthermore, the Greek government has to invest in new technologies for both diagnosis and treatment, which will improve the accessibility and availability of quality health services for all citizens and thus provide early and accurate diagnosis and efficient treatment. In the long term this will also benefit the health economics of the country. Finally, steps have to be made concerning compliance with the EU Basic Safety Standards and the IAEA/WHO recommendations concerning the professional status of medical physicists, the registration scheme and continuing professional development (CPD).*

ASSOCIATION OF HEALTH – RESEARCH & BIOTECHNOLOGY INDUSTRY (SEIV)

The meeting with the Hellenic Association of Health – Research & Biotechnology Industry (SEIV) took place on 14 September 2017 at SEIV's premises in Athens.

Present on behalf of SEIV: Mr Pavlos Arnaoutis, President; Mr John Baferos, Director; Mr Gerry Livadas, General secretary; Mr Dimitris Kapatsoris and Mr Yannis Pratikakis, representatives of Siemens Healthcare ABEE.

Present on behalf of WHO/INBIT: Professor Nicolas Pallikarakis, INBIT President of the board; Dr Aris Dermitzakis, Biomedical engineer.

Attendees agreed that while Greece has a large number of CT and MRI scanners, this becomes significantly lower when old units are not taken into account. They estimate that if all devices over 12 years old were withdrawn then the number of available units would decrease by approximately 50%. In Germany, all HVCE is renewed every 10 years. It was also stressed that EOPYY reimbursement is not dependent on the age of the equipment.

Regarding the acquisition of HVCE, it was pointed out that devices can be imported from abroad without restrictions. As a result, even the manufacturing companies have no clear idea of the devices imported by third parties. These devices can be old and/or not properly maintained, yet still used for medical practice and eligible for reimbursement from EOPYY. In other countries it is forbidden to import old equipment or even equipment refurbished by the manufacturer.

On the topic of procurement specifications, it was stressed that public hospitals still use the old Research Centre for Biomaterials (now EKAPTY) specifications. These still apply outdated specifications, despite technological progress (i.e. smaller generators are needed as doses in CT scanning have been decreased but buyers still seek higher-powered generators). Additionally, in many cases requirements are not in accordance with real needs. This results in acquisitions of equipment with features that will never be used by the hospital and is more expensive than necessary.

EEAE is responsible for measuring and checking the doses applied to patients In Greece. Quality control is also performed by each manufacturer/authorized representative. In terms of vigilance, all manufactures are obliged to share any information on adverse events concerning their devices. However, this is impossible as they are not aware of all the devices operating in the country.

It was also stressed that there is a very important issue concerning the software available in the market. The case of picture archiving and communication systems (PACSs) was cited as an example – anyone can download a free digital imaging and communications in medicine (DICOM) viewer, connect it with a database and sell it as a PACS.

HELLENIC SOCIETY OF RADIOLOGY (HELRAD)

The meeting with the Hellenic Radiology Society took place on 17 October 2017 at their premises in Athens.

Present on behalf of HelRAD: Professor Panos Prassopoulos, President.

Present on behalf of WHO/INBIT: Professor Nicolas Pallikarakis, INBIT President of the board.

After a presentation of the objectives and aims of this study, the sources of information and the data collected so far were presented and discussed extensively.

According to HelRAD, diagnostic radiology equipment (CT & MRI) in Greece is generally rather old, thereby influencing the quality of health services supplied. Decisions on purchasing new equipment to cover new needs, or replace old and obsolescent machines in the public sector, are not evidence based. Procedures and rules on priority settings are not well-defined according to real needs for different medical procedures that equipment should be able to cover. For example, each public hospital should have at least one CT unit of recent technology. The age of equipment of this type should not exceed eight to 10 years but, following cost-effectiveness evaluation for use, older equipment could continue to run for less demanding procedures. In the private sector the costs of diagnostic tests should be controlled and reimbursed according to the technology used. The installation of refurbished equipment should be restricted and maintenance contracts should be obligatory in order to minimize breakdown time and assure quality of output and patient safety, amongst other things.

It is necessary to establish and apply guidelines on the number of diagnostic and therapeutic acts related to the technologies in question. This is required in order to protect patients; avoid misuse and overuse with unnecessary exams; and ensure that reimbursement is dependent on prescriptions in accordance with these guidelines.

Finally, Professor Prassopoulos stressed that the education and training of radiologists is a key factor. The system applied today dates from 1994 since when the sector has experienced a very rapid evolution. This is mainly due to new technological developments and a radical restructure of this system is necessary to serve current needs. HelRAD has already worked out proposals for both guidelines and educational issues, and is committed to continue to work in this direction.

Annex 2. Population data (Census 2011)

All population-related data presented have been calculated based on the latest revised results of the 2011 census. All data are available from the Hellenic Statistical Authority;[2] analytical data are available only in the Greek language.

Επίπεδο διοικητικής διαίρεσης	α/α	Γεωγραφικός κωδικός Καλλικράτη	Περιγραφή	Μόνιμος Πληθυσμός
4	20948	99	ΑΓΙΟ ΟΡΟΣ (ΑΥΤΟΔΙΟΙΚΗΤΟ) (Εδρα: Καρυαί,αι)	1811
4	11327	38	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΑΙΤΩΛΟΑΚΑΡΝΑΝΙΑΣ (Εδρα: Μεσολόγγιον,το)	210802
4	15937	49	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΑΝΑΤΟΛΙΚΗΣ ΑΤΤΙΚΗΣ	502348
4	17531	59	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΑΝΔΡΟΥ	9221
4	13588	41	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΑΡΓΟΛΙΔΑΣ (Εδρα: Ναύπλιον,το)	97044
4	12878	40	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΑΡΚΑΔΙΑΣ (Εδρα: Τρίπολις,η)	86685
4	5008	19	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΑΡΤΑΣ (Εδρα: Άρτα,η)	67877
4	10526	37	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΑΧΑΪΑΣ (Εδρα: Πάτραι,αι)	309694
4	8145	28	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΒΟΙΩΤΙΑΣ (Εδρα: Λεβάδεια,η)	117920
4	15829	46	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΒΟΡΕΙΟΥ ΤΟΜΕΑ ΑΘΗΝΩΝ	592490
4	3529	15	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΓΡΕΒΕΝΩΝ (Εδρα: Γρεβενά,τα)	31757
4	292	02	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΔΡΑΜΑΣ (Εδρα: Δράμα,η)	98287

2 http://www.statistics.gr/documents/20181/1210503/resident_population_census2011rev.xls/956f8949-513b-45b3-8c02-74f5e8ff0230].

Επίπεδο διοικητικής διαίρεσης	α/α	Γεωγραφικός κωδικός Καλλικράτη	Περιγραφή	Μόνιμος Πληθυσμός
4	16228	50	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΔΥΤΙΚΗΣ ΑΤΤΙΚΗΣ	160927
4	15889	47	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΔΥΤΙΚΟΥ ΤΟΜΕΑ ΑΘΗΝΩΝ	489675
4	500	03	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΕΒΡΟΥ (Εδρα: Αλεξανδρούπολις,η)	147947
4	8374	29	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΕΥΒΟΙΑΣ (Εδρα: Χαλκίς,η)	210815
4	9008	30	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΕΥΡΥΤΑΝΙΑΣ (Εδρα: Καρπενήσιον,το)	20081
4	9982	33	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΖΑΚΥΝΘΟΥ (Εδρα: Ζάκυνθος,η)	40759
4	12187	39	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΗΛΕΙΑΣ (Εδρα: Πύργος,ο)	159300
4	1611	08	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΗΜΑΘΙΑΣ (Εδρα: Βέροια,η)	140611
4	18684	71	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΗΡΑΚΛΕΙΟΥ (Εδρα: Ηράκλειον,το)	305490
4	775	04	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΘΑΣΟΥ	13770
4	5396	20	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΘΕΣΠΡΩΤΙΑΣ (Εδρα: Ηγουμενίτσα,η)	43587
4	1249	07	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΘΕΣΣΑΛΟΝΙΚΗΣ (Εδρα: Θεσσαλονίκη,η)	1110551
4	17652	60	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΘΗΡΑΣ	18883
4	10125	34	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΙΘΑΚΗΣ	3231
4	16862	54	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΙΚΑΡΙΑΣ	9882
4	4141	18	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΙΩΑΝΝΙΝΩΝ (Εδρα: Ιωάννινα,τα)	167901
4	824	05	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΚΑΒΑΛΑΣ (Εδρα: Καβάλα,η)	124917
4	17752	61	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΚΑΛΥΜΝΟΥ	29452
4	6403	23	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΚΑΡΔΙΤΣΑΣ (Εδρα: Καρδίτσα,η)	113544
4	17857	62	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΚΑΡΠΑΘΟΥ	7310

Επίπεδο διοικητικής διαίρεσης	α/α	Γεωγραφικός κωδικός Καλλικράτη	Περιγραφή	Μόνιμος Πληθυσμός
4	3729	16	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΚΑΣΤΟΡΙΑΣ (Εδρα: Καστοριά,η)	50322
4	17928	63	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΚΕΑΣ - ΚΥΘΝΟΥ	3911
4	15801	45	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΚΕΝΤΡΙΚΟΥ ΤΟΜΕΑ ΑΘΗΝΩΝ	1029520
4	9548	32	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΚΕΡΚΥΡΑΣ (Εδρα: Κέρκυρα,η)	104371
4	10158	35	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΚΕΦΑΛΛΗΝΙΑΣ (Εδρα: Αργοστόλιον,το)	35801
4	1805	09	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΚΙΛΚΙΣ (Εδρα: Κιλκίς,το)	80419
4	3119	14	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΚΟΖΑΝΗΣ (Εδρα: Κοζάνη,η)	150196
4	13886	42	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΚΟΡΙΝΘΙΑΣ (Εδρα: Κόρινθος,η)	145082
4	17990	64	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΚΩ	34396
4	14247	43	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΛΑΚΩΝΙΑΣ (Εδρα: Σπάρτη,η)	89138
4	5917	22	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΛΑΡΙΣΑΣ (Εδρα: Λάρισα,η)	284325
4	19390	72	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΛΑΣΙΘΙΟΥ (Εδρα: Άγιος Νικόλαος,ο)	75381
4	16573	53	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΛΕΣΒΟΥ (Εδρα: Μυτιλήνη,η)	86436
4	10399	36	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΛΕΥΚΑΔΑΣ (Εδρα: Λευκάς,η)	23693
4	16987	55	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΛΗΜΝΟΥ	17262
4	6860	24	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΜΑΓΝΗΣΙΑΣ (Εδρα: Βόλος,ο)	190010
4	14882	44	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΜΕΣΣΗΝΙΑΣ (Εδρα: Καλαμάτα,η)	159954
4	18033	65	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΜΗΛΟΥ	9932
4	18125	66	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΜΥΚΟΝΟΥ	10134

Επίπεδο διοικητικής διαίρεσης	α/α	Γεωγραφικός κωδικός Καλλικράτη	Περιγραφή	Μόνιμος Πληθυσμός
4	18150	67	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΝΑΞΟΥ	20877
4	16329	52	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΝΗΣΩΝ	74651
4	15910	48	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΝΟΤΙΟΥ ΤΟΜΕΑ ΑΘΗΝΩΝ	529826
4	1023	06	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΞΑΝΘΗΣ (Εδρα: Ξάνθη,η)	111222
4	18326	68	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΠΑΡΟΥ	14926
4	16307	51	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΠΕΙΡΑΙΩΣ	448997
4	2071	10	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΠΕΛΛΑΣ (Εδρα: Έδεσσα,η)	139680
4	2307	11	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΠΙΕΡΙΑΣ (Εδρα: Κατερίνη,η)	126698
4	5689	21	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΠΡΕΒΕΖΑΣ (Εδρα: Πρέβεζα,η)	57491
4	19829	73	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΡΕΘΥΜΝΟΥ (Εδρα: Ρέθυμνον,το)	85609
4	5	01	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΡΟΔΟΠΗΣ (Εδρα: Κομοτηνή,η)	112039
4	18423	69	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΡΟΔΟΥ	119830
4	17086	56	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΣΑΜΟΥ (Εδρα: Σάμος,η)	32977
4	2469	12	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΣΕΡΡΩΝ (Εδρα: Σέρραι,αι)	176430
4	7166	25	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΣΠΟΡΑΔΩΝ	13798
4	17478	58	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΣΥΡΟΥ	21507
4	18600	70	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΤΗΝΟΥ	8636
4	7215	26	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΤΡΙΚΑΛΩΝ (Εδρα: Τρίκαλα,τα)	131085
4	7628	27	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΦΘΙΩΤΙΔΑΣ (Εδρα: Λαμία,η)	158231
4	3929	17	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΦΛΩΡΙΝΑΣ (Εδρα: Φλώρινα,η)	51414

Επίπεδο διοικητικής διαίρεσης	α/α	Γεωγραφικός κωδικός Καλλικράτη	Περιγραφή	Μόνιμος Πληθυσμός
4	9292	31	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΦΩΚΙΔΑΣ (Εδρα: Άμφισσα,η)	40343
4	2845	13	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΧΑΛΚΙΔΙΚΗΣ (Εδρα: Πολύγυρος,ο)	105908
4	20271	74	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΧΑΝΙΩΝ (Εδρα: Χανία,τα)	156585
4	17248	57	ΠΕΡΙΦΕΡΕΙΑΚΗ ΕΝΟΤΗΤΑ ΧΙΟΥ (Εδρα: Χίος,η)	52674

Annex 3. Regional distribution of HVCE, 2017

Regional sector	MUs	CT	MRI	γ-camera	RT	PET
Athens Central	98	51	33	28	12	4
Athens North	59	32	32	16	14	3
Thessaloniki	57	37	36	23	11	2
Piraeus	28	25	11	8	6	2
Larissa	17	11	10	6	3	
Achaea	18	11	9	6	3	
Heraklion	20	8	7	7	2	
Athens West	27	15	12	6	2	
Ioannina	8	4	6	3	2	
Evros	11	8	5	3	2	
Athens South	40	19	16	6		
Kozani	7	6	4	3		
Attica East	25	13	13	2		
Pella	8	6	5	2		
Messenia	7	4	5	2		
Lesbos	5	4	3	2		
Corfu	4	4	3	2		
Kavala	6	3	3	2		
Trikala	6	3	3	2		
Drama	3	4	2	2		
Serres	5	3	2	2		
Rhodes	10	4	4	1		
Corinth	9	4	4	1		
Karditsa	4	4	4	1		
Chania	6	3	4	1		
Euboea	16	5	3	1		

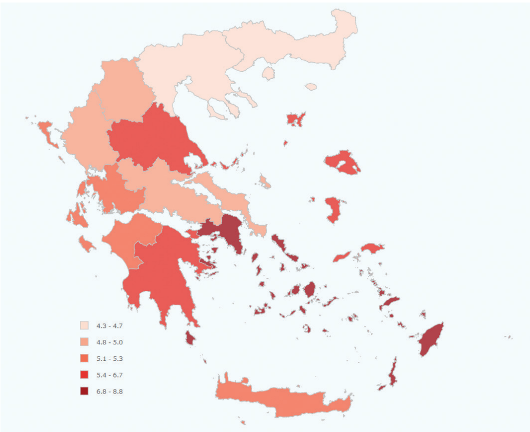
Regional sector	MUs	CT	MRI	γ-camera	RT	PET
Magnesia	9	5	3	1		
Chios	6	4	3	1		
Phthiotida	6	4	3	1		
Xanthi	3	2	3	1		
Boeotia	8	6	2	1		
Rhodope	4	3	2	1		
Imathia	10	4	1	1		
Pieria	3	3	1	1		
Laconia	5	2	1	1		
Arcadia	3	4	7			
Aetolia-Acarnania	13	8	6			
Argolis	10	5	3			
Attica West	7	5	3			
Elis	7	4	2			
Rethymno	6	3	2			
Preveza	4	2	2			
Zakynthos	4	2	2			
Naxos	3	2	2			
Kos	4	1	2			
Lasithi	6	4	1			
Islands	6	3	1			
Chalkidiki	5	2	1			
Arta	4	2	1			
Kastoria	4	2	1			
Kilkis	3	2	1			
Syros	3	2	1			
Thesprotia	3	2	1			
Cephalonia	2	2	1			
Mykonos	2	2	1			
Samos	2	2	1			
Thira	2	2	1			
Kalymnos	2	3				
Grevena	2	2				

Regional sector	MUs	CT	MRI	γ-camera	RT	PET
Lemnos	2	2				
Florina	5	1				
Paros	3	1				
Lefkada	2	1				
Sporades	2	1				
Evrytania	1	1				
Phoctheis	1	1				
Ikaria	1	1				
Andros	1					
Karpathos	1					
Milos	1					
Ithaca						
Kea-Kythnos						
Thasos						
Tinos						

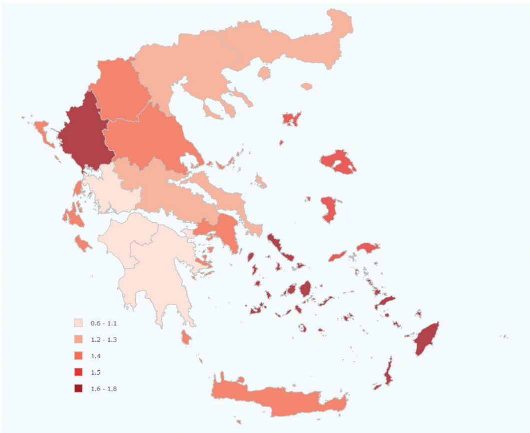
Annex 4. Mapping of distribution of units and exams

MAMMOGRAPHY UNITS (MUS)

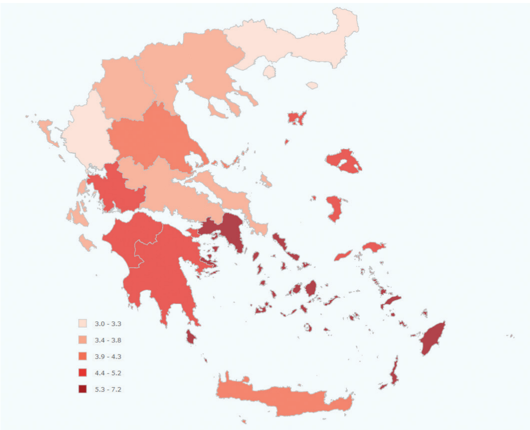
Total number of units per 100 000 inhabitants



Public-sector number of units per 100 000 inhabitants

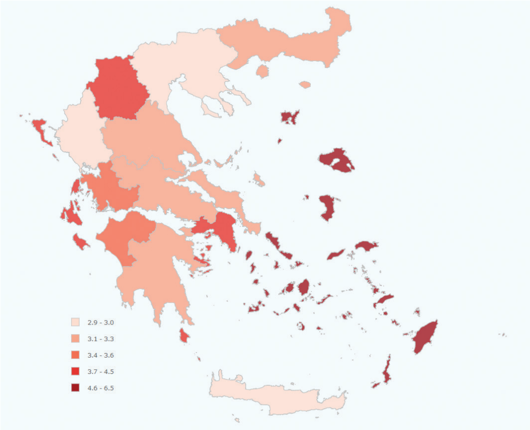


Private-sector number of units per 100 000 inhabitants

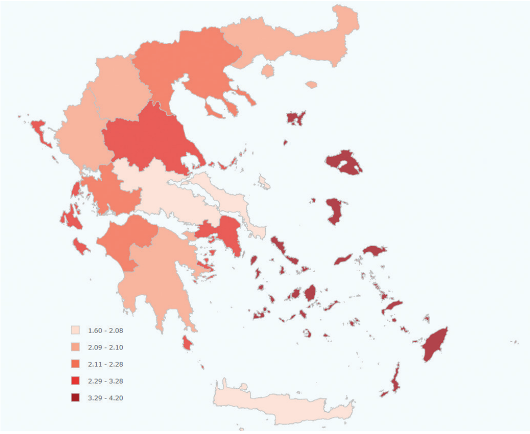


COMPUTED TOMOGRAPHY (CT) UNITS

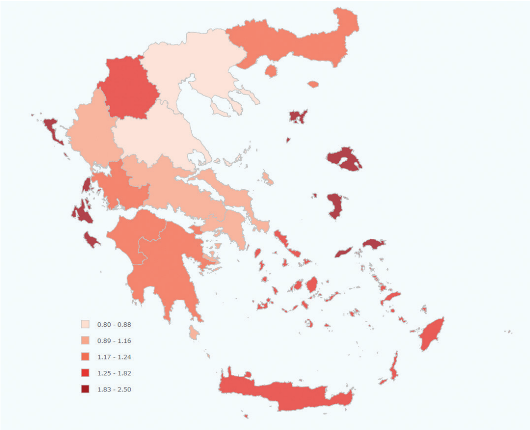
Total number of units per 100 000 inhabitants



Private-sector number of units per 100 000 inhabitants

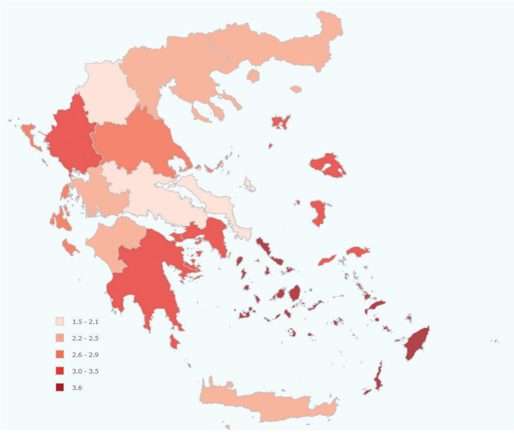


Public-sector number of units per 100 000 inhabitants

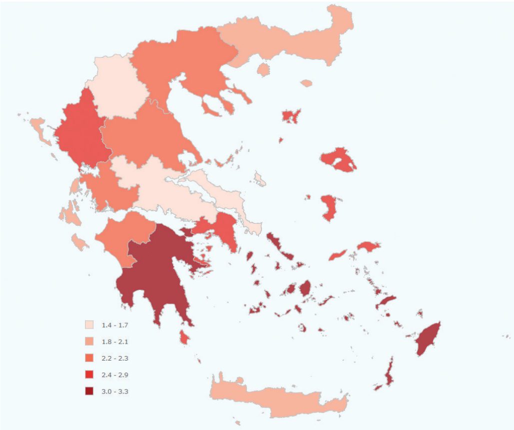


MAGNETIC RESONANCE IMAGING (MRI) UNITS

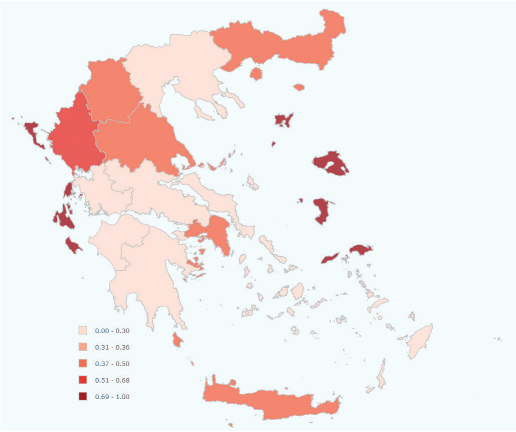
Total number of units per 100 000 inhabitants



Private-sector number of units per 100 000 inhabitants

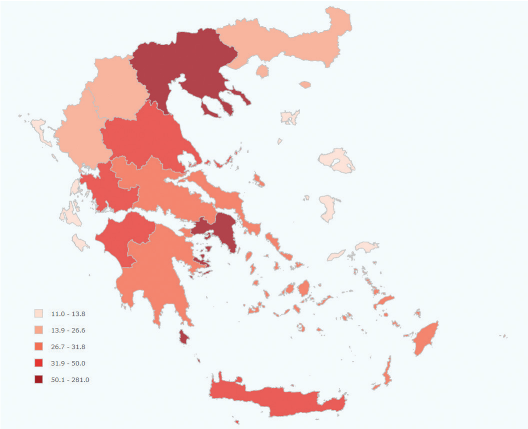


Public-sector number of units per 100 000 inhabitants

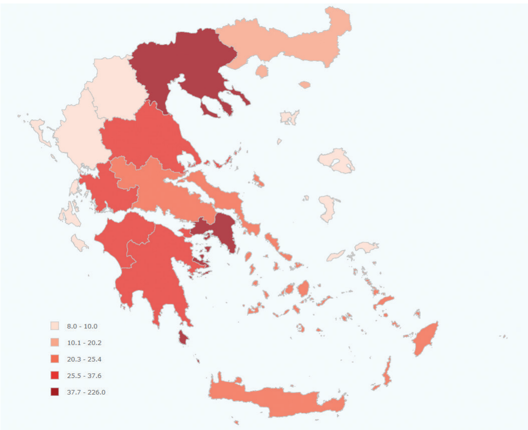


MAMMOGRAMS

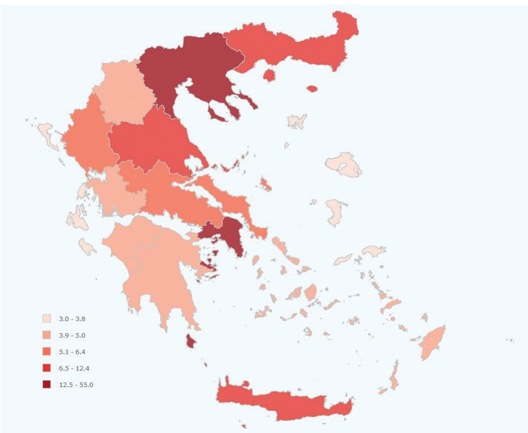
Total number of exams per 1000 inhabitants



Private-sector number of exams per 1000 inhabitants

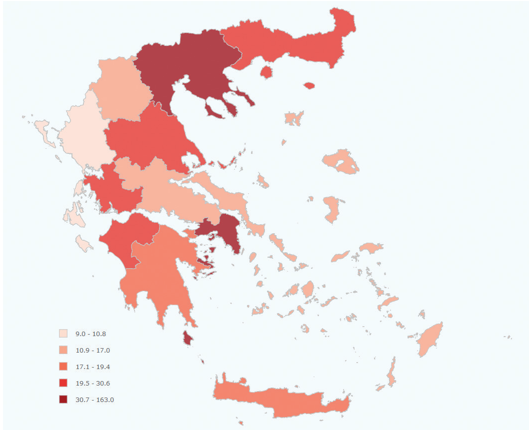


Public-sector number of exams per 1000 inhabitants

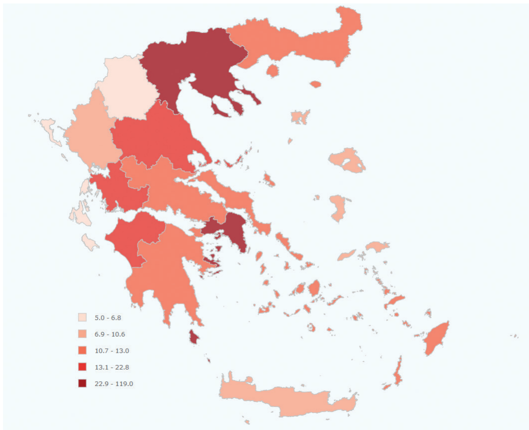


CT SCANS

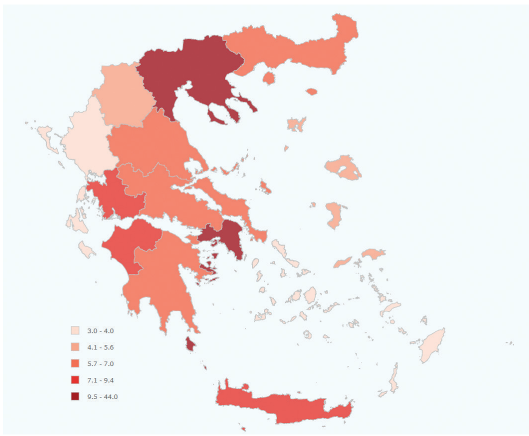
Total number of exams per 1000 inhabitants



Private-sector number of exams per 1000 inhabitants

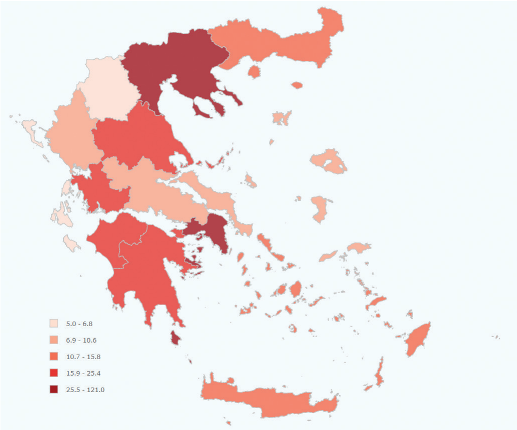


Public-sector number of exams per 1000 inhabitants

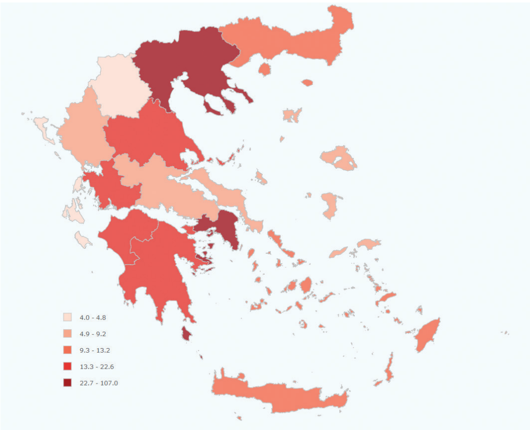


MRI SCANS

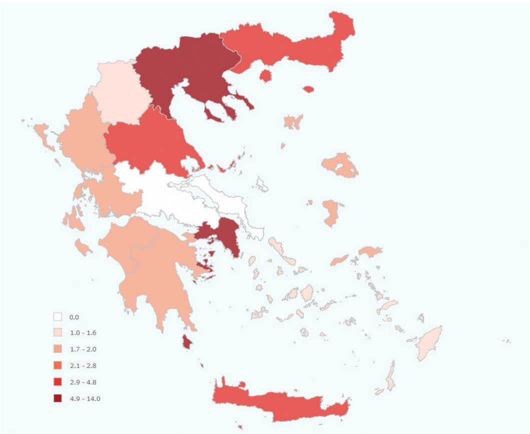
Total number of exams per 1000 inhabitants



Private-sector number of exams per 1000 inhabitants



Public-sector number of exams per 1000 inhabitants



The WHO Regional Office for Europe

The World Health Organization (WHO) is a specialized agency of the United Nations created in 1948 with the primary responsibility for international health matters and public health. The WHO Regional Office for Europe is one of six regional offices throughout the world, each with its own programme geared to the particular health conditions of the countries it serves.

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