

Medical Informatics Education & Research in Greece

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Summary

Objectives: This paper aims to present an overview of the medical informatics landscape in Greece, to describe the Greek ehealth background and to highlight the main education and research axes in medical informatics, along with activities, achievements and pitfalls.

Methods: With respect to research and education, formal and informal sources were investigated and information was collected and presented in a qualitative manner, including also quantitative indicators when possible.

Results: Greece has adopted and applied medical informatics education in various ways, including undergraduate courses in health sciences schools as well as multidisciplinary postgraduate courses. There is a continuous research effort, and large participation in EU-wide initiatives, in all the spectrum of medical informatics research, with notable scientific contributions, although technology maturation is not without barriers. Wide-scale deployment of eHealth is anticipated in the healthcare system in the near future. While ePrescription deployment has been an important step, ICT for integrated care and telehealth have a lot of room for further deployment.

Conclusions: Greece is a valuable contributor in the European medical informatics arena, and has the potential to offer more as long as the barriers of research and innovation fragmentation are addressed and alleviated.

Keywords

Medical informatics, ehealth, education, research, Greece

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1 Introduction

Medical Informatics concerns the management of biomedical information, data, and knowledge, and their deployment (including analysis) for improvement of medical decision-making. The research spectrum is broad, from analysis of biosignals and genetic data, to development of medical information systems and pervasive health applications as well as personal health systems for patients and healthy individuals. The nature of Medical Informatics research entails involvement in multidisciplinary, close link between domain / user needs and technology push, continuous loops of discovery and application, i.e. generating new knowledge and exploration of new procedures. All of the above interact with and transform the medical practice, the healthcare delivery, as well as the attitudes of all involved actors. Therefore multiple technological, social and governance-related factors contribute to the progress, and sometimes resistance to progress, of Medical Informatics education and research, as well as to the path for wide deployment and reimbursement of eHealth solutions.

While Medical Informatics aims on eHealth adoption and improvement of healthcare, as a function of quality and cost, at the same time, its application, adoption and acceptance are also affected by the general public computer literacy, the overall e-governance legislation and policies, and the overall IT infrastructures and services available. At the same time, one of the qualities and advantages of Medical Informatics education and research is the potential to produce knowledge and innovation, without

necessarily the need for high cost lab investments. Within this framework, after more than two decades of Medical Informatics education and research in Greece, this paper aims to describe and discuss the current status and challenges.

The paper is organized as follows. Section 2 describes the Medical Informatics educational landscape in Greece, as regards both undergraduate and postgraduate studies, and exposure of health professionals to ICT (Information and Communication Technologies) for health technologies. Section 3 discusses Medical Informatics research. First, in subsection 3.1, the eHealth infrastructure in Greece is presented, including various nation-wide efforts and established actions. Following, in subsection 3.2, the characteristic Greek Medical Informatics research initiatives are discussed entailing different aspects of patient-centered care research. Finally, in subsection 3.3, issues of Research and Innovation Support are tackled, as regards continuity of research, and support of innovation and research maturation. Discussion and concluding remarks are presented

2 Medical Informatics Education and Academia

The Lab of Medical Informatics in the Medical School of Aristotle University belongs to the pioneers in Medical Informatics education (1990), thus introducing biomedical research and multidisciplinary. Historically, it started with the aim to introduce electronic

health concepts in the Greek Medical ecosystem and train young scientists and professionals in medicine/health. It introduced such curricula at undergraduate (School of Medicine and School of Dentistry, Aristotle University of Thessaloniki (AUTH)) and graduate level. Gradually, more schools followed, and currently labs and units of Medical Informatics, eHealth technology, digital health, etc., exist at the Universities of Athens, Crete, Ioannina, Patras, Piraeus, Peloponnese, Thessaly, and Thrace.

As reported by the WHO regional information for Greece [1], the ICT for health capacity building is offered as ICT training for students in health sciences at tertiary institutions as well as Institutions offering continuing education in ICT for health professionals, including Medical, Nursing, Public health, Dentistry, Pharmacy Professional groups. In the same study, introduction of eLearning technologies in health sciences at the tertiary level was recognized, both in teaching health sciences and in training health professionals. When barriers to eLearning are identified these were mostly attributed to lack of skilled course developers, lack of knowledge of applications, perceived high costs and availability of suitable courses. An ongoing effort in this direction takes place in all

programs. Among others, it is interesting to note that the open archives digital science and culture content repository (<http://www.openarchives.gr/>) of the Greek National Documentation Centre currently includes 35 entries tagged as “medical informatics”.

Regarding the graduates studies in Medical Informatics and similar topics, typically they are inter departmental built under the collaboration among Medicine, Biology, Engineering and Informatics departments, and accepting students from multiple relevant disciplines. The AUTH inter departmental program in Medical Informatics [2], organized by the Medical School, the School of Electrical and Computing Engineering and the School of Informatics of Aristotle University, was established in 1998, including first a 2-year MSc curriculum, and following this a PhD in Medical Informatics. The Programme has already awarded 131 MSc degrees, and 18 PhD degrees with 8 more PhD candidates continuing up to now. The MSc part is built upon basic and applied aspects in Medical Informatics, with a strong orientation in research evolving on three main axes, namely the Biomedical Technology, the Medical Information management and big-biodata analytics and the Telemedicine and Personal Health Systems. Additionally, Medical Informatics is a core module in the

Medical Research Methodology MSc program of the AUTH Medical School. Other educational programs were organized (in Universities of Athens and Patras) within the last decade, in relative domains, entitled for example “Informatics for Life Sciences”, or “Information Technologies in Medicine and Biology”, also attracting students with a first degree/diploma in Medicine, Biology, Engineering and Informatics. In addition, various Research Centers in Greece, e.g., CERTH, FORTH, ICCS, include Institutes, laboratories and units that focus on Medical Informatics post-graduate education through research.

In the national repository of PhD theses, part of the National Documentation Centre (<http://phdtheses.ekt.gr/>), a non-exhaustive search with relevant keywords (medical informatics, biomedical technology, biosignal, telemedicine, ehealth, biosensor, medical information system, hospital information system, electronic patient record), yielded 154 theses in the last 20 years, with a gradually increasing rate. Their distribution in different sub-topics, as presented in Figure 1 (left), suggests a rather balanced representation of different areas of interest in medical informatics. The increase of PhDs in the last decade over the previous one is clearly illustrated in Figure 1 (right).

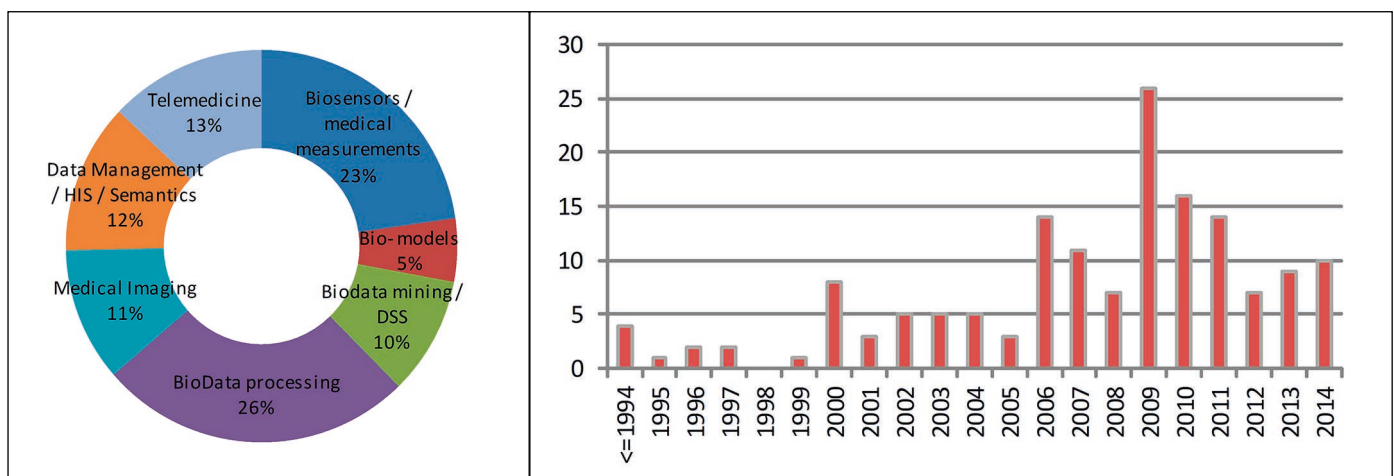


Fig. 1 (left) Distribution of the PhDs in different sub-topics. (right) distribution of the medical informatics PhDs per year.

3 Medical Informatics Research

3.1 The eHealth Infrastructure in Greece

In the Greek NHS, financing is provided by a combination of social insurance and general taxation and the public or private sectors offer services. Regional health authorities have been established since 2001, and are currently named DYPE (Administration of Regional Health Services). Although efforts for the introduction of ICT in public health care system had begun already in the mid' of 80s, the results have not yet reached the desired expectations.

In private primary care, computerized patient records are increasingly adopted, without however following a common standard. In primary public care computerized patient records exist, but to a great extent these are experimental or prototype, and certainly not standard and uniform [3].

A major step for standardization has been the adoption and use of the unified national Social Security Number (AMKA) assigned to every person covered by a Greek social insurance fund, mandatory since the 1st of October 2009. The number is assigned through the public insurance organizations.

Under the current legal framework (Law 3892/2010 Electronic Recording of Prescription), prescription and dispense of medications is performed electronically (Figure 2). National e-Prescription was introduced in 2010 and today has more than 98% national coverage, with 6 million e-prescriptions per month (98,5%) and 1.5 million e-referrals per month (92%) [4-5]. The nationwide e-Prescription system has been deployed by the Ministry of Health and is accessible by authorized users only (physicians and pharmacists). Prescriptions contain patient's social security number, diagnosis (encoded in ICD-10), medicines (quantity, dosage) and patient's participation share of payment of each drug, etc. The system is based on interoperability and security standards (HL7 CDA, IHE ATNA, respectively), interconnects with pharmacies information systems through a CDA based RESTful API (Application Programming Interface), in order to automatically dispense

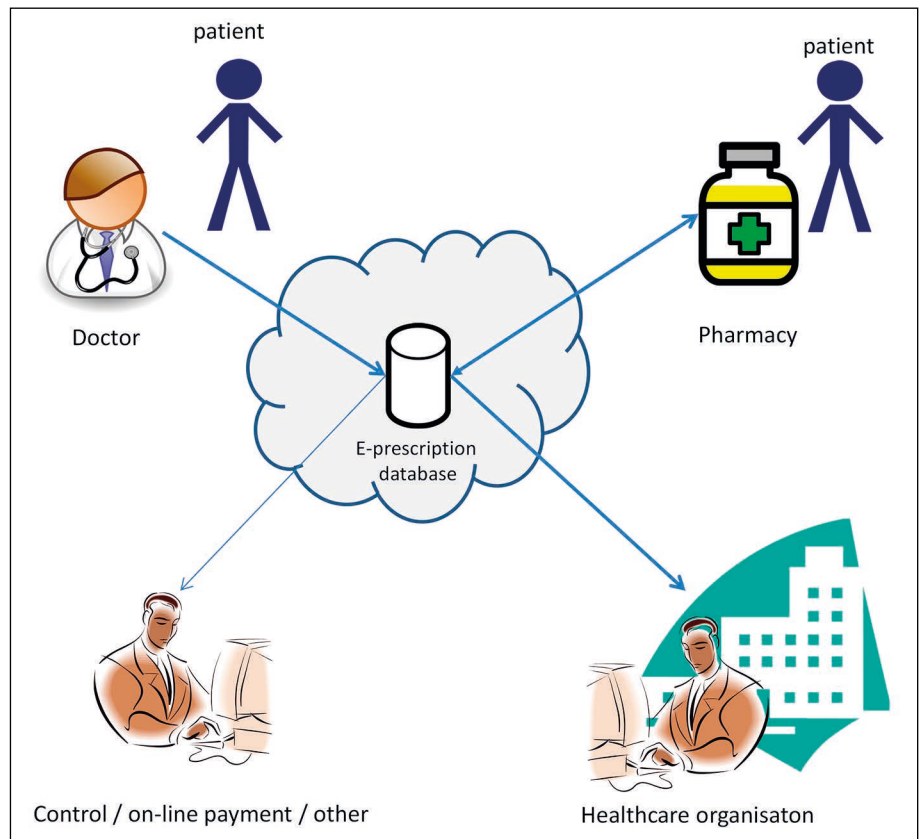


Fig. 2 An overview of the e-prescription and the users involved.

electronic and hand-written prescriptions. Among the recognized pitfalls of the system is the difficulty among physicians in selecting the correct, for each patient, ICD diagnosis among thousands possible ones so that it can be used for patient safety applications and management of ADEs and medication adherence [6].

Telehealth programs are not established nation-wide, and their penetration to deployment beyond pilot phases varies at regional level. However, due to the geographical distribution of the population, with many small communities residing in rather isolated islands and remote rural regions, the telehealth solution has been always regarded as an attractive challenge and, thus, numerous efforts and pilots have taken place, accumulating a significant research experience in the field, as well as a rather wide dissemination and lately acceptance.

Among the first success stories was HygeiaNet [7], the Regional Health Infor-

mation Network of Crete. HygeiaNet aimed for an integrated electronic health record, based on an open architecture and tools for the integration of specialized autonomous applications, encompassing also for ehealth and mhealth services (eHealth Collaboration Environment, Integrated Care Solutions, Pre-hospital Health Emergency Management System, Primary Health Care Center Information System, and more). HygeiaNet had a coverage along the entire island of Crete, the biggest Greek island (8,303 km²) with few cities and many small and remote villages. A notable successful example in Central Greece, is the Municipality of Trikala which in collaboration with secondary care has installed telehealth services for chronic patients (Chronic Heart Failure, Chronic Asthma or COPD, Arrhythmias and Hypertension) to improve their daily life. Vital signs are recorded at home, transferred to the hospital and reviewed by experts, who then provide the necessary feedback.

Another ongoing program of wide coverage is the Vodafone Greece Telemedicine Program, implemented to 100 areas across Greece, focusing on enabling remote health screening of citizens especially at geographically disperse areas.

Despite some bright examples, based on a EU-wide survey [8], Greece is overall behind the European average in terms of eHealth development (Figure 3), especially as regards “PACS usage” (-39%), “Exchange of clinical care information with external providers” (-37%), “Exchange of laboratory results with external providers” (-32%) and “Exchange of radiology reports with external providers” (-38%). However, Greece presents progress higher than EU average in “ePrescribing” (47%) and “Integrated system for eReferral” (33%). As regards composite indicators on deployment and availability, which are based on “EHR; Clinical Decision Support on EHR; Health Information Exchange; and Telehealth”, Greece eHealth Composite Indicators in 2012 measure below average EU, but with an increasing trend in deployment.

3.2 Medical Informatics and Patient-centered Care Research

Greek Academia and Research Organizations has a long term continuous presence in Medical Informatics research and participates in a series of EU-funded projects on ICT for Health, as regards ehealth infra-

structures and pervasive health platforms, biomedical signal and image analysis, as well as physiological modelling.

An important step towards uptaking electronic health record system was the Greek participation in epSOS project (<http://www.epsos.eu/>) for cross-country Patient summary and e-prescription support [9], which facilitated the incorporation of epSOS-friendly prescriptions in the National e-Prescription system. After epSOS completion, SO-Health (Smart Open Internet Services for Health, <http://www.sohealth.gr/>) project co funded by the Greek Secretariat of Research and Technology and the European Union, continued as a national extension of established European innovation projects and networks (epSOS, Calliope, Antilope). In addition, via participation in the EXPAND Thematic Network (<http://www.expandproject.eu/>), large-scale deployment of cross-border care among Member States will be supported.

Closely bound to e-prescription, the issue of medication errors and preventable adverse events has been the focus of the PSIP (Patient Safety through Intelligent Procedures in medication) FP7 EU-funded integrated project. In PSIP, the Lab of Medical Informatics, AUTH, led the design and development of contextualized decision support modules for adverse drug event prevention following a knowledge-based approach [10]. The project demonstrated via successful prototypes the integration of decision support modules in two commercial IT systems, a CPOE

(Computerized Physician Order Entry) and an EHR [11]. Interestingly, in a comparative international study concerning the attitude of physicians towards automatic alerting in CPOE systems with Greek participation, it was found that despite the fact that CPOE systems are not well-established in Greece, physicians recognize their value and their potential contribution in quality of care and patient safety [12].

As the national health policy is oriented towards boosting primary care and fully networking secondary care, use cases and technologies are explored. As an example, the nationally funded project PINCLOUD (Providing Integrated eHealth Services for Personalized Medicine utilizing Cloud Infrastructure) explores the capabilities of cloud platforms for the development and deployment of innovative integrated ehealth services, integrating primary care, hospital, and telehealth programs, and personal health records [13]. At a European level, a unified platform for ambient assisted living (AAL) services has been developed by the universAAL an EU FP7 project [14], and an interesting AAL test-bed has been deployed by the REMOTE project funded by the AAL program [15]. Both projects had a strong Greek participation (including research centers and companies).

In parallel to health data and biodata management and development of ehealth platforms, intelligent systems and integrated services have been at the center of interest for Medical Informatics groups in Greece. Among the worth noting examples, Symbiosis [16] is an innovative system (designed and developed by a group of students at the Electrical and Computer Engineering Department of Aristotle University of Thessaloniki) that created a novel environment to facilitate, understand and incorporate the needs of the whole Alzheimer community (patients, caregivers and doctors). Greek Medical Informatics groups have been involved in a series of EU projects for management of chronic non-communicable diseases (FP7:Dem@Care for Dementia, FP7:Heartcycle, for CHD and HF, ICT-PSP:LLM for Alzheimer's, FP7:CHRONIOUS for COPD). Among the most notable recent efforts for the advancement of coordinated care, the WELCOME EU

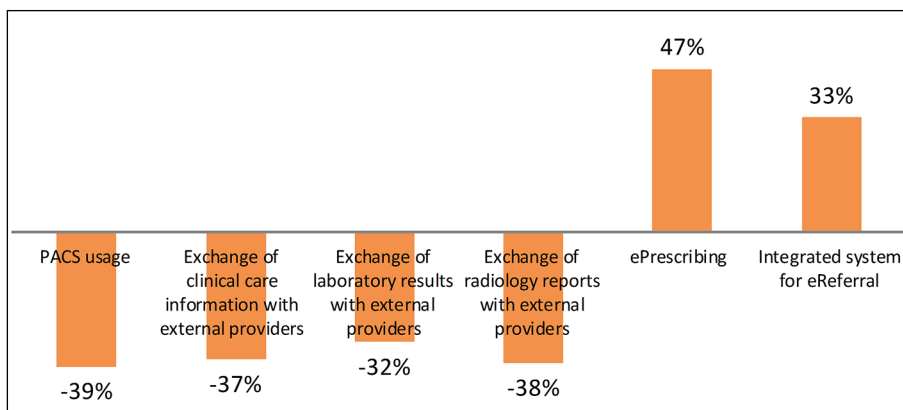


Fig. 3 Greece position in terms of eHealth development with respect to European average.

project [17] develops advanced contextualized cloud-based services for the patients with COPD and comorbidities, as well as their carers and health professionals.

In parallel with development of care coordination, provision of personalized medicine is a basic pillar for patient-centered care. In this respect, medical informatics research works focus on physiological modelling and translational research. Characteristic projects with important Greek participation include CHIC [18] and ContraCancrum for multiscale cancer modeling, p-medicine [19] for integrative personalized medicine platforms, PIPAVIR for human papillomaviruses (<http://www.pipavir.com/>).

In the domain of accessibility and eInclusion notable FP7 EU integrated projects constitute Cloud4all (<http://cloud4all.info/>) and Prosperity4all (<http://www.prosperity4all.eu/>), which build the main components of the Global Public Inclusive Infrastructure (GPII, <http://gpii.net/>), again with strong Greek participation in technical development [20], evaluation and user involvement.

3.3 Research and Innovation Support

On the other hand, the Medical Informatics community in Greece is well connected via HL7-Hellas, Greek Health Informatics Association, EMBC – Greek Chapter, EAMBES, VPH-institute, and is active in nurturing the Connected Health Ecosystem and European Connected Health Alliance through the Greek eHealth forum that is active over the past two years. Outreach and dissemination activities, workshops and conferences in Medical Informatics/Biomedical Engineering take place with a steady rate in Greece (for example, BIBE, Mobihealth, Medicon, pHealth, Petra, ICIMTH).

At EU level, Greek Medical Informatics research has been steadily funded by the EU research programs. Indicatively, as it concerns the area of HEALTH research, which is the target area of Medical Informatics fusion and convergence at large, in terms of Greek participation in FP7-HEALTH projects (accepted proposals) between 2007-2013 [21], as well as IMI projects in the period 2009-14, the percentages are depicted in Figure 4.

The decline in year 2010 FP7-HEALTH projects might be related to overall social matters due to the start of the economic crisis period.

Among the 113 FP7-HEALTH projects with Greek participation

- 89 were Collaborative Projects (with 112 Greek participants)
- 21 Coordination and Support Actions including 2 ERANETs (with 24 Greek participants)
- 3 Networks of Excellence (with 3 Greek participants).

In terms of activity areas, the distribution is summarized in Figure 5.

In IMI 9 Greek participants that belong to 7 unique organizations are involved in 7 IMI projects, with EC financial contribution 2,98 Mio. Euros (0,4% of the total EC contribution for IMI), distributed to Research institutions (39,5%) followed by Others (33%), Academia (24%) and Private sector (3.5%).

In terms of IT infrastructure, it is worth mentioning that okeanos (<https://okeanos.grnet.gr>) cloud service (Virtual Machines, Networks and Storage), developed and freely

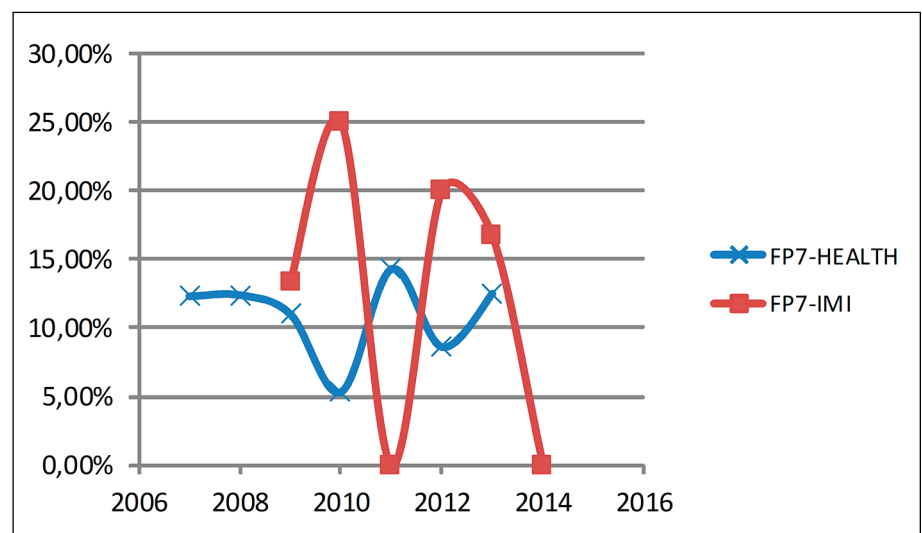


Fig. 4 FP7-HEALTH and IMI percentage of accepted proposals with Greek participation.

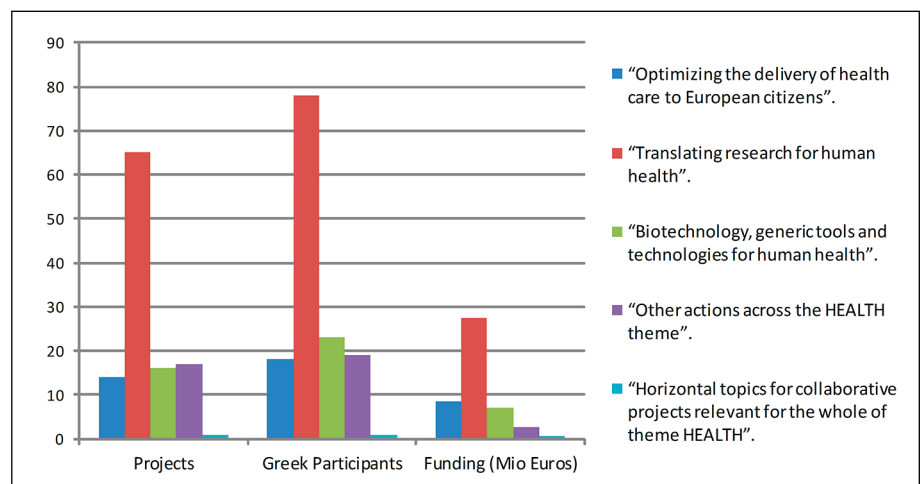


Fig. 5 FP7-HEALTH distribution in Activities, with respective Greek participants, and Funding.

provided by Greek Research and Technology Network (GRNET) for the benefit of the Greek Research and Academic Community, since 2011, has helped to balance the gap between needs and IT provision among academic labs, and has provided a stable R&D environment.

At national level, eHealth calls for national funding are well aligned with EU. eHealth Innovation is encouraged and supported by several public and private bodies, including General Secretariat of Research and Technology (Extraversion - Competitiveness of Enterprises), Ministry of Development & Competitiveness (New Innovative Entrepreneurship), Ministry of Education (Education and Lifelong Learning), Hellenic Federation of Enterprises, Private institute scholarships for postgraduate studies, and State Scholarships Foundation. However, support tends to be fragmented, irregular and intermittent, and links between academia and industry are not robust, thus maturation of eHealth technology is not well supported as an end-to-end process.

4 Discussion

As reported in the WHO eHealth survey in 2009 [1], among the barriers to implementing telemedicine solutions, the ones recognized for Greece are “*Lack of legal policies/regulation*”, “*Organizational culture not supportive*”, “*Competing priorities*”, “*Lack of nationally adopted standards*”. Regarding information most needed in country to support telemedicine development, the major points recognized were “*Cost and cost effectiveness*”, “*Clinical possibilities*”, “*Evaluation*” and “*Patients’ perception*”. Additionally, barriers to implementing mHealth initiatives were “*Competing priorities*”, “*Lack of policy framework*”, “*Cost effectiveness unknown*”, “*Lack of legal policies/regulation*”. Clearly, despite progress in medical informatics research and education, ehealth policy and governance issues play an important role in actual adoption of health technologies. These problems have been recognized and efforts are made at multiple levels, academia, industry and authorities, for example, introduction of national standards

in medical coding and medical procedures. However, there is still space to be covered in order for Medical Informatics in Greece to meet its full potential. Generating evidence via wider application and evaluation of various medical informatics solutions, including telemedicine applications, could help familiarize Healthcare professionals and patients with these approaches, and thus change perceptions, while also providing concrete evidence on its benefits in care.

It is worth mentioning that Greece participates with the Lab of Medical Informatics in the Aristotle University in the EU programmes ACT (<http://act-programme.eu/>) and iTECH (<http://www.itech-project.eu/>), which attempt to evaluate the coordinated care services and the healthcare technology, respectively, attempting to set a solid basis for the comparison and evaluation of approaches at regional level and across multiple dimensions, in order to eventually provide concrete tools and guidelines for the alleviation of barriers to eHealth and even more to connected health and translational medicine. Interestingly, ACT project is one that applies a specific link of the EIP on Active and Healthy Ageing (EIP-AHA) with the Greek eHealth community and the regional health delivery systems.

At the moment, there are actions in setting up a more coordinated ecosystem for the EIP on AHA through the establishment of the Greek NGO on EIP on AHA under the auspices of the Ministry of Health, as well as a need to build regional ecosystems for the uptake of the eHealth systems on a regional level, and in certain cases on a national level. It is envisaged that the solid scientific and academic Greek nucleus in the eHealth area as well as the increased medical community awareness of the eHealth possibilities through the undergraduate and graduate programs available in the medical schools as well will help in the future development of the Greek eHealth and AHA national ecosystem.

5 Conclusions

Greece has participated in the European Medical Informatics arena for more than two decades with important interventions in

second and third generation tele monitoring systems [22,23], has educated a big number of scientists and healthcare professionals in the field and has significant achievements not only in research but also in piloting and deployment of eHealth and personal health systems [24] paving the way to connected health, VPH and big bio-data management and analytics future platforms and enhanced eHealth services. Addressing a series of barriers related to research and innovation fragmentation, as well as policies and health governance, is expected to help unfold its full potential towards the academia and society.

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