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INFORMATION AND COMMUNICATION TECHNOLOGY: ELECTRONIC HEALTH RECORD AS SUSTAINABLE CHOICE IN SOUTHERN EUROPE IN THE EUROPEAN CONTEXT*

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Abstract. Following the European outlook, in the reform context, as declared by the European Government Law related to National Health Service, the countries are implementing Information and Communication Technology (ICT) and Electronic Health Records (EHR). The present research assesses the degree of ICT and EHR and its sustainability in diffusion and adoption across southern Europe cities' hospitals. It outlines the framework of European ICT to evaluate the different degrees of EHR present in southern Europe. The evaluation of the degree of diffusion and adoption of EHR is based on the Southern Europe Inpatient Dataset. It shows how the EHR is in close correlation with ICT policies and how it can also affect such policies.

Keywords: Europe; Sustainability; Cross Hospital Comparative Study; Cities; HER, ICTs diffusion and adoption

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Additional disciplines: Healthcare, Government Policy, Technological Change, Public Health.

1. Introduction

Information and Communication Technology (ICT) provides both opportunities and challenges for redesigning economic and service structures in terms of production and information worldwide. Therefore, it is unsurprising that many European countries are implementing ICT processes. These processes are strictly linked to ICTs (Marino et al., 2022), and one of the main goals is to ensure the creation of continuous value in health (Squitieri et al., 2017; Zhao et al., 2019; Caratas et al., 2021). Following this research stream is strategic to ensure and activate ICT tools because it could allow for keeping and add to the creation of value in health as in the case of public

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services (i.e. health, education, national and local services). The research in this study is focused on ICT tools with particular reference to ICTs diffusion and how these two factors affect European Health to create value in the public health sector (Capone et al., 2020). These actions are strictly linked to how the European government operates at the micro and macro levels using ICT (Bloom et al., 2019). The complexity of service delivery has increased over the years as the expectation for transparency of the citizen part, especially in a sector with high technological innovation level (Hwang & Christensen, 2008; Ash, 1997; Gardner et al. 2007; Marino, 2001, Marino & & Tamburis 2005; Lehoux et al. 2019; Piccinetti et al., 2023). Recent studies highlighted the original character of the ICT and how a government should realize the value of health (van Gemert-Pijnen et al., 2011; Oh et al., 2005; Eysenbach, & Jadad, 2001; Marino et al., 2020; Benjamin, et al. 2019). Interestingly, these studies align with other conceptual research in which it emerged that the creation of PVs requires work in alignment, coordination, and co-creation. Creating PVs means changing the programs of public departments. These changes have been implemented in many countries and have produced interesting value in health (Kelly et al., 2019; Norman & Skinner, 2006; Casado-Vara & Corchado, 2019). Such changes are related to departments' communication, coordination and integration regarding the new services delivered. These actions and decisions highlight the necessity to negotiate procedures and reorganize the budget and department employees. A recent study argues that these processes are functional in generating positive value in health (Iqbal et al., 2019; Porter & Kramer, 2019; Urena et al., 2019; Finkelstein et al., 2019). The governments are operating in a continuously changing context. According to literature (Chohan, 2019; Williams & Shearer, 2011; O'Flynn, 2007) conceptualizations of public value, the government can improve the collective and individual service delivery (Besley & Ghatak, 2007; Romzek et al., 2014; Mamokhere, 2023). In this sense, the output of a government is aimed at improving public value as a collective goal. Public value means that public interest and the common good should be the main concern of the public sector. Interestingly, this approach considers the citizens as effective stakeholders in public value in health creation (Cluley & Radnor 2020; Mintrom & Luetjens, 2017; Bryson et al., 2014). The citizens can determine a higher level of democracy and legitimate the government within two processes of democracy: bottom-up and top-down. Furthermore, the ICTs are strategic drivers for enhancing public value in health. They may be fundamental tools in optimising processes to increase the stakeholders' engagement by including the employees in a network governance logic. The governments might have to manage and deliver information and services and gain legitimization in an interactional logic with stakeholders. In this context, ICTs can propose new service delivery ideas and models. Interesting contributions consider ICTs as enabling factors to create public value in health. (Martins et al., 2019; Ferlie et al., 2019; Cronemberger & Gil-Garcia, 2019; Twizeyimana & Andersson, 2019). For example, ICT can contribute by improving efficiency and introducing innovation in the delivery of services, by enriching hospital-patient relationships with employees, and by strengthening trust in and support for and legitimacy of health organizations (Miller et al., 1997; Palanisamy & Thirunavukarasu, 2019). Following this research stream, ICT is an enabling factor to empower hospitals, patients, and health services and support inclusive practices, especially for the different processes at the national and local levels (Cooper et al., 2019; Krebs & Duncan, 2015). Furthermore, recent studies highlight the potential of ICTs in creating value in health by enhancing ICTs-relations to assess intra-hospital services, which produce added value in health. It is interesting to note the different approaches to value in health, Porter (2010, p.2) argues that: "*Outputs, not inputs, measure value. Hence the value of health care depends on the actual patient health outcomes, not the volume of services delivered. More care is not always better, and shifting focus from volume to value is a central challenge. Nor is the value measured by the process of care utilized; process measurement and improvements are important tactics but no substitutes for measuring outcomes and costs*". Following this definition, Mosadeghrad (2013, p.1) proposes a different definition: based on "*consistently delighting the patient by providing efficacious, effective and efficient healthcare services according to the latest clinical guidelines and standards, which meet the patient's needs and satisfies providers*". The evolution of these studies related to the value of ICT is in Capone et al. (2020), with special reference to Electronic Health Records (EHR) and one of the results shows that EHR systems can improve the value of health. Following this research stream, value in health and EHR, Leventer-Roberts et al. (2020, p.216), in the conclusion of the paper, argues that "*linking individuals' health records with their data-derived family history has untapped potential for supporting diagnostic and*

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clinical decision-making." The studies based on EHR point out that each public hospital should promote more interactive and active contributions to decision-making through the timely sharing of information and communication. The result of this process is that ICT would contribute to creating value in health by improving hospitals' actions regarding value and transparency of public services. All these positive elements present a weakness linked to the decision-making process between professional instances (medical, nursing, technological) and choices of the public health service. (Adler-et al. 2015; Desautels et al., 2016; Tavares & Oliveira, 2016). On the one hand, assessing the value of health provision delivery has become strategic over the last few years. On the other hand, governments need to guarantee transparency and encourage stakeholder collaborative participation. Following this research stream, specific applications to create value in health have been applied (Graber et al., 2019; Kruse et al., 2016). In the recent period, February 2020, ICT and EHR have been considered a strategic asset also in response to the health emergency of Covid-19. In this context, European countries are turning to massive use of ICT to create an effective balance between the value of health services and lockdowns. The level of ICT diffusion also represents the extent to which each country is operating in the development, effectiveness, and efficiency of both human and economic advancement (Marino et al., 2021). This development process involves the creation of culture and investments in network building by including in the public and private fields several sectors (i.e., education, health, economies) at different levels (i.e., service delivery, production process). In this context, it is fundamental for European countries to be able to implement the processes of diffusing and integrating ICT within their societies to translate the benefits into economic development (European Policy E-Health, 2020). The divergence in ICT accessibility and disparity of digital opportunities within the European country, with a different distribution among its hospitals, may create bottlenecks in developing value in health. Although this phenomenon has tended to contract, it is still a critical issue for many European countries (Tuikka et al., 2016; Grossman et al., 2016). The ICT is in close correlation with EHR implementation, and use the chance to access this tool efficiently represents, on the one hand, the countries' ability to provide innovative digital services through adequate infrastructures and, on the other, to guarantee all patients, full access to the opportunities offered by ICT tools. Europe shows a different degree of ICT and EHR implementation and use within its territory, with great differences between the regions. This issue represents an important bottleneck to developing ICT

1.1. European Context

ICT and EHR in the European context have the potential to significantly contribute to improving healthcare quality, efficiency, and patient outcomes. However, sustainability issues need to be addressed to ensure the long-term viability and effectiveness of EHR systems. Interoperability and Data Exchange: One key sustainability issue is interoperability among EHR systems. In Europe, a fragmented landscape with multiple EHR platforms and standards hinders the seamless exchange of patient information across healthcare providers and regions. Achieving interoperability is crucial to ensure the continuity of care, reduce duplication of tests and procedures, and improve overall healthcare efficiency. Privacy and Data Security: Protecting patient privacy and ensuring the security of EHR data are significant sustainability concerns. Strict privacy regulations, such as the General Data Protection Regulation (GDPR) in the European Union, necessitate robust security measures and consent management systems. Adhering to these regulations while maintaining the accessibility and usability of EHR systems is a delicate balance that needs ongoing attention. Long-term Maintenance and Upgrades: EHR systems require continuous maintenance, upgrades, and infrastructure support to remain functional and up to date. Ensuring adequate funding and resources for these activities is crucial to prevent system obsolescence and maintain the usability and effectiveness of EHR systems over time. User Adoption and Training: User acceptance and engagement are critical factors for the sustainability of EHR systems. Adequate training and support for healthcare professionals are necessary to encourage adoption and ensure efficient utilization of EHR functionalities. User-friendly interfaces, transparent workflows, and ongoing user feedback mechanisms can help address usability challenges and promote sustained adoption. EHR Impact: The sustainability of EHR systems also extends to their environmental impact. Energy consumption, e-waste generation, and carbon emissions

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associated with data centres and hardware infrastructure must be minimized. Adopting energy-efficient technologies, optimizing data storage and retrieval processes, and promoting responsible e-waste management practices are essential for reducing the environmental footprint of EHR systems.

Furthermore, a recent study commissioned by the European Union, "Interoperability of Electronic Health Records in the EU" (EU, 2022), highlights that the implementation of the EHR has had a limited impact in some Member States of the European Union. In this context, south Europe highlights a series of bottlenecks related to implementing this technology in the public health sector. The data in the report show the general trend for the individual Member States with a comparison between them, without highlighting any imbalances present within the individual EU countries to their division by geographical area: in the case of southern Europe. Electronic health records in southern Europe have yet to become a reality. In this context, it is useful to understand the main dynamics blocking the development of EHR in southern Europe. This study assesses EHR diffusion and adoption across southern Europe cities and elaborates on the framework of ICT to evaluate the different degrees of digital health present in European southern cities and can help to understand how this issue may develop European health service. The present analysis will interest researchers, policymakers and government planners, who can acquire information for developing national ICT strategies. The paper is organized as follows: section two outlines a conceptual background on ICT and EHR. Section 3 shows the methodology, section 4 displays the results, and section 5 discusses the European experience. Finally, section 6 shows the conclusions of the paper.

2. Conceptual Background

The studies on the EHR, starting from a technological point of view, highlight the strategic role of ICT and the extent of the missed opportunities when they are not exploited. Moreover, the EHR is linked to a gap identified as a social issue between European countries. (Katehakis et al., 2011; McGinn et al., 2011; Emmanouilidou, & Burke, 2013). In line with this point of view, EHR was first linked to ICT access and only later to the development of the information society. (Al Aswad et al., 2013; Nguyen et al., 2014; Coorevits et al., 2013). These papers represented a critical literature review of some studies on the means of electronic health records. These studies analyzed the advantages and disadvantages of EHR from different perspectives and viewpoints. The main perspectives of these studies are related to adopting electronic health records in different European countries to trace the current status of adopting this technology. These studies highlight the importance of adopting electronic health records and the differences among European countries. The relevant outcomes are linked to the critical points related to the no adoption of EHR. These critical points are related to the organizational, technological and managerial gaps. These critical points concern national and local health services and the absence of one European Health Service. However, these papers will follow a critical review method of the adoption of EHR, starting with its implementation in European countries, highlighting that at an organizational level, the critical points are linked to the need that while organizations implement ICT to effect change, current culture and procedures are pay insufficient attention to the change goals. Following this research stream, hospitals, service delivery, and the medical culture are developed and studied (Strong et al., 2014; Kazley & Ozcan, 2007). The ICT impact is multilevel in the organizational change process. At the ICT level, it is interesting to note that future hospital success depends on managing, accessing, using, and reusing information. (Miriovsky et al., 2012; Buntin et al., 2011). Managerial ones should support the organizational and technological levels. At the managerial level, the studies cited above suggest that management provides medical ICT training and pays attention to it as a strategic outcome. If this training is done ineffectively can increase managerial risks (Terry et al., 2008). These variables, linked to organizational, technological and managerial tools, are important to support the hospital information systems. These three approaches determine an important step forward in assessing the EHR because it is associated with efficient usage and information access. These studies were always limited and not strongly linked to both pathology and cities context in which strategic hospitals deliver health services. Only in recent years, the literature developing studies in this research line and Europe, less than at the worldwide level. (Martel et al., 2018; Aldosari, 2017; Saleem & Herout, 2018; Fukami & Masuda, 2019; Joukes et al., 2019). In

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line with this assumption, it is important for the future of the European health service. It will be studied with the adoption of EHR because recent reforms assign a central role to the strategic hospitals of the city to implement public health policies. The reform proposed by the central government must be implemented at the local level. In this framework, the Public Administration is the main actor in implementing EHR activity (Fernández-Cardeñosa et al. 2012). In this context, the reform is more complex than the ICT as a technological, organizational and managerial issue, evolving into the information society concept. In line with this assumption, the EHR is studied as a European global issue, a strategic decision in all cities with strategic hospitals from northern to southern Europe. In line with this assumption, it is important to study the future of European health service, particularly the adoption of EHR, and recent reforms, to assign a central role to the strategic hospitals of the city to implement public health policies. The reform proposed by the central government will be implemented at the local level. The pillars related to EHR adoption are care, research and governance. Firstly, the care related to prevention, diagnosis, treatment and rehabilitation. This pillar aims to sustain the Institutions of the National Health Service, the Local-Health Service that takes care of the patient. Secondly, the research related to the medical, biomedical and epidemiological sectors. This pillar aims to deliver, by National Health, economic resources within their respective responsibilities assigned by law. Thirdly, governance is linked to the quality of care and evaluation of health care to assess organizational, technological and managerial issues. The aims are to coordinate, integrate and control Local Health Services within their respective responsibilities assigned by law. The debate, linked to EHR in cities with strategic hospitals, highlights the different roles of innovation: organizational, financial, operative (process and service delivery), management, managerial and technological. These are useful for the decision-making process of each city government to establish the course of action to improve the public value of Local Health Services. Currently, the Covid-19 emergency forces many countries to strengthen ICT adoption and invest in this way in ICT. For instance, a large part of Europe, particularly the Southern European experience (Marino et al., 2022) and other European Countries are characterized by very few opportunities for innovative action related to ICT adoption. It is interesting to note that the European government underlines the importance of better performance related to the National Health Service through the capacity to utilize the opportunities created by ICT to disseminate information and knowledge to improve individual and collective choices. At the European local level, regions and cities, local governments recently and later point out that disparities between cities' ICT widely mirror disparities in income and other socio-economic factors. In many European cities, large portions of the population are out of the information society network and risk becoming outcasts. Governments should aim at removing disparities linked to existing access inequalities. Governments must overcome the function of those who provide services; they should focus on reforming the public national health service in which the ICT and EHR are strategic bottlenecks that hinder communication between patients and health. In this logic, if governments want to implement EHR, they must shed the role of service provider supervision, create favourable conditions, and ensure equal opportunities for all. This is the design of inclusion. A new frame of mind focused on inclusion is required, particularly in the European southern cities. Particularly, as Research Question (RQ) in southern Europe, and its cities, there is still much to do to bridge the ICT and EHR. Will it be possible? The next section, methodology, deals with the approach adopted to answer the question.

3. Methodology

3.1. Data Source

Starting from data 2022 of the Eurostat Inpatient Database (EID), the following variables are considered: Healthcare Cost (HC) as Bed Utilization Rate (HCBUR), Reservation Unique Center and Quality (RUCQ), to assess the following cities' hospitals:

- Athens, Sparta, Corinth, (Greece - GR).
- Madrid, Barcelona, San Sebastian, (Spain- SP).
- Naples, Bari, Palermo, (Italy - IT).

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- Lisbon, Porto, Coimbra, (Portugal - PO).

This shows the implementation status of EHRs; in these 12 cities are all provincial capitals or metropolitan cities. The EID collects data from the hospitals. The hospitals are public because EID does not collect data from private health. In the selected cities, there are the most significant number of hospitals in the region and are strategic about the guidelines of the reform law. These hospitals collect large numbers of patients as residents and people of the region. The hospitals considered have adopted all the EHR during the year 2019. The EID is a European database containing information on patient characteristics, diagnoses, and procedures. The EID database contains information on Electronic Health Record (EHR) utilization in different hospitals, along with other important hospital characteristics. Both surgical and medical patients from several diagnostic categories were included in the study. These categories were chosen based on the RUCQ dataset and classified as an acute diagnosis - ICD9 CM (2020). The most acute diagnoses are concentrated in a range between 5 and 20 days with relative occupancy of the Bed Utilization Rate. In the considered time, there is remission or the patient's death. These variables set up Hospital Organizational Indicator (HOI). Each HOI includes a unique denominator, numerator, and set of risk adjustors.

3.2. Statistical Analysis

Correlation analysis, also known as bivariate, is primarily concerned with determining whether a relationship exists between variables and then determining the magnitude and action of that relationship. The HOI is based on European codes and Medicare severity diagnosis-related groups (DRGs), with criteria determined by the RUCQ. Using Statistical Package for Social Science software (version 26) has been possible to identify adverse events in our dataset. Univariate regression analysis has been developed to obtain descriptive statistics. A hierarchical regression relating to the level of EHR utilization and quality of care was developed. The independent variables are:

- no EHR; (level of EHR utilization)
- partial EHR; (level of EHR utilization)
- full EHR; (level of EHR utilization)
- patient demographics;
- pathology;
- medical group;
- surgical group.

The dependent variables are:

- mortality;
- readmissions.

measured by HOIs.

Relative-risk difference (RrD) used by RUCQ, has been considered to implement an EHR system that may improve quality care. All considered, hospitals have implemented EHR since 2012. This comparison is important to eliminate some types of potential confounding. The use of EHR was split into 3 groups: those that gained full EHRs by 2022 (treatment 1), those that gained only partial EHRs by 2019 (treatment 2), and those that still had no EHRs in 2022. Directly comparing these groups to obtain a logic sequence about EHR use, the rates in 2019 are compared with the same hospital's in 2022. The changes (rates) are used to compare the treatment, i.e., EHR adoption level with no EHR adoption. All statistical analyses were performed using SPSS version 26.0.

4. Result

To answer the RQ and create an accumulation of knowledge linked to RQ highlighted in the conceptual background, tables 1 and 2 display patient characteristics as explained in the methodology.

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Table 1. Surgical Patient by EHR Status – 2022

	N	No EHR	Partial EHR	Full EHR
Procedure	**Total**	159859	2.70	57.84
	NSTEMI	44.693	3.70	52.00
	STEMI	7793	3.22	56.68
	ANG	9890	2.70	58.63
	PUE	14.748	1.49	51.53
	CATAM	74.613	2.85	55.76
	VEFI	8122	3.00	58.44
Cities				
	Naples (IT)	42.292	13.05	56.72
	Madrid (SP)	31.232	7.62	54.32
	Barcelona (SP)	33.324	5.54	57.83
	Lisboa (PO)	9232	6.32	53.64
	Athens (GR)	25.346	5.63	54.68
	Coimbra (PO)	18.433	4.32	58.63
Age range				
	18 to 39	2945	2.48	56.78
	40 to 64	62.634	3.02	57. 66
	65 to 74	39.824	2.33	58.75
	>75	54.456	2.78	56.76
Pay ticket				
	exemption	36.686	2.82	56.42
	partial	104.384	2.32	57.34
	full	18789	2.12	55.43

Source: Our Elaboration on Eurostat 2019 - 2022–
Legenda: Heart Attack NSTEMI Code ICD: 41071; Acute myocardial infarction STEMI Code ICD: 41091; Angina ANG Code ICD: 4111; Pulmonary embolism PUEM Code ICD: 41519; Cardiac tamponade CATAM Code ICD: 4239; Ventricular fibrillation VEFI Code ICD: 42741

Table 2. Medical patient by EHR Status – 2022

	N	No EHR	Partial EHR	Full EHR
Condition	**Total**	332362	2,38	59,72
	Emergency	144.693	3,70	62,00
	Planned	87794	3,11	68,08
	Day Hospital	99875	2,30	55,63
Hospital				
	Naples (IT)	82.246	14,05	54,72
	Madrid (SP)	52.214	9,62	64,32
	Barcelona (SP)	49.124	12,54	60,83
	Lisboa (PO)	45.123	4,32	63,64
	Athens (GR)	53.184	15,63	59,68
	Coimbra (PO)	50.471	8,32	54,63
Age range				
	18 to 39	4283	2,48	66,78
	40 to 64	72.755	5,02	67,66
	65 to 74	69.262	4,33	56,75
	>75	186.062	4,78	59,76
Pay ticket				
	exemption	134.481	6,82	59,42
	partial	179.118	3,32	58,34
	full	18763	4,12	57,43

Source: Source: Our Elaboration on Eurostat 2019 - 2022

A total of 159859 surgical and 332362 medical patients, RID dataset, were included. Table 1, surgical patients display 2.7% were treated with no EHR, 57.8% were treated with partial EHR, and 39.7% with full EHR. The surgical patients with a major number of acute diagnoses are NSTEMI and CATAM (see legenda table 1). In

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these two diagnoses, NSTEMI displays no EHR, 3.70, partial, 52 and full 43.3, and CATAM displays no EHR 2.85, partial, 55.7 and full 41.3. Furthermore, also in other three acute diagnoses: STEMI, ANG e VEFI, and EHR use, display the same trend, with full modality always as last place. The cities with the major number of acute diagnoses considered (see legenda Table 1) are Napoli (Italy), Madrid (Spain), and Barcelona (Spain). These three cities, in two different European Member States, confirm other considered cities also share the last place in full EHR and this trend. The age range displayed is 40 to 64 and >75, with significant numbers of population (N). Following the trend, also in this case full EHR is the last place. Pay ticket display as first modality, partial payment with exemption at second. Also, in this case full EHR is the last modality. Table 2, medical patients, 2.3 were treated in a hospital with no EHR, 59.7 patients were treated with partial EHR, and 37.9 with full EHR. Naples (Italy), with 13 hospitals, is the first city in the Campania Region, and the first in the ranking of population (N) affected to acute diagnosis considered. In these hospitals, full EHR is the last modality and this position is the same in all considered Hospitals in the cities of ranking. Population after Naples displays the following ranking: Madrid (Spain), 9 hospitals, N = 52214, Athens (Greece), 8 hospitals, N= 53184, Coimbra (Portugal), 7 hospitals, N = 50471, Barcelona 5 hospitals, N = 49124 and Lisboa, 2 hospitals, N = 45123. The cities considered, have the major numbers of Hospitals in each Region, Madrid (Spain) and Athens (Greece) display a major percentage of partial EHR. Assessing the population with a variable age range, full EHR is the last modality, and partial ticket payment is the first modality linked to population (N). In this case, full EHR is the last amount percentage for all variables. Table 3, cross-sectional analyses, surgical and medical patients treated with full EHR and mortality rates (1.5) more than patients treated with partial EHR (1.3) but treated with no EHR (1.5) (*R-value* 0.0084). Emergency, with full EHR rates (11.9) is more than both partial and no EHR, (*R-value* 0.0006). Planned with full EHR rates (3.7) is more than partial and no EHR, (*R* value <0.0001). Day Hospital, shorter length of stay, with full EHR (7.1) less than partial and no EHR (*R-value* <0.0001).

Table 3. Cross-sectional univariate analysis of surgical and medical patient condition by EHR Status – 2022

Condition	Group	No EHR	Partial EHR	Full EHR	R value
Died %	Total	**1.54**	**1.35**	**1.55**	**0.0084**
	NSTEMI	1.52	2.22	2.36	0.0963
	STEMI	10.78	11.67	13.87	0.1213
	ANG	3.04	3.03	3.07	0.7118
	PUE	2.12	1.55	1.65	0.8655
	CATAM	1.16	0.70	0.84	0.2812
	VEFI	1.07	0.07	0.08	0.0234
Emergency %	Total	**11.46**	**10.30**	**11.93**	**0.0006**
	NSTEMI	14.62	14.65	14.67	0.8202
	STEMI	0.00	17.63	20.32	0.0534
	ANG	10.34	11.46	12.43	0.3520
	PUE	7.23	11.46	9.75	0.0174
	CATAM	11.65	10.45	11.34	0.8446
	VEFI	11.03	9.08	9.07	0.0122
Planned %	Total	**3.22**	**3.07**	**3.74**	**<0.0001**
	NSTEMI	4.35	6.27	7.35	<0.0001
	STEMI	3.13	12.16	13.23	0.2054
	ANG	2.35	3.43	4.54	0.4133
	PUE	3.65	4.13	4.33	0.5321
	CATAM	4.62	3.49	3.86	0.1614
	VEFI	1.62	1.10	1.27	0.0545
Day Hospital %	Total	**7.69**	**7.85**	**7.18**	**<0.0001**
	NSTEMI	14.35	10.27	10.55	<0.0001
	STEMI	13.13	12.16	12.23	0.9054
	ANG	4.35	3.23	3.24	0.3133
	PUE	9.65	7.13	6.33	0.0021
	CATAM	7.62	6.49	5.86	0.0014
	VEFI	3.62	3.10	3.27	<0.0001

Source: Source: Our Elaboration on Eurostat 2019 - 2022–

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Cities and hospital patients (see Table 4) display that the first condition (dead) is within a range of 0.11 with *an R-value* of 0.0096; the highest percentage is linked to full EHR (1.7). Emergency displays at the last place partial EHR and full EHR at first place but the difference with no EHR is 0.19, *R-value* 0.0075. Planned, display no EHR with 3.2, partial 3.0 and full 3.7 with *R-value* <0.0001. Day hospital, display with no EHR 7.2, partial with 7.4 and full EHR 7.3, *R-value* <0.0001. These last two conditions display differences between the three modalities of EHR (no, partial and full), particularly in planned condition (0.50) while in Day hospital is 0.09 with the same *R-value.*

Table 4. Cross-sectional univariate analisys of cities and hospital patient condition by EHR Status – 2022

Condition	Group	No EHR	Partial EHR	Full EHR	R value
Died %	Total	**1.64**	**1.55**	**1.75**	**0.0096**
	Naples (IT)	1.82	2.33	2.42	0.0982
	Madrid (SP)	10.67	16.77	10.87	0.1236
	Barcelona (SP)	13.04	13.73	11.57	0.9116
	Lisboa (PO)	2.82	11.58	1.63	0.8456
	Athens (GR)	1.13	0.60	0.74	0.2721
	Coimbra (PO)	1.77	0.67	0.07	0.0225
Emergency %	Total	**12.54**	**11.34**	**12.73**	**0.0075**
	Naples (IT)	14.22	14.15	14.17	0.8292
	Madrid (SP)	10.70	13.63	21.32	0.0634
	Barcelona (SP)	20.34	21.46	22.43	0.5720
	Lisboa (PO)	17.23	12.47	11.77	0.0197
	Athens (GR)	13.65	11.45	14.44	0.8668
	Coimbra (PO)	21.03	8.08	10.07	0.0128
Planned %	Total	**3.22**	**3.07**	**3.74**	**<0.0001**
	Naples (IT)	4.75	6.37	7.15	<0.0001
	Madrid (SP)	13.13	12.16	13.23	0.2134
	Barcelona (SP)	2.55	3.13	4.54	0.4133
	Lisboa (PO)	3.65	4.23	4.13	0.6321
	Athens (GR)	4.82	3.79	3.46	0.1662
	Coimbra (PO)	1.82	1.34	1.87	0.0845
Day Hospital %	Total	**7.29**	**7.45**	**7.38**	**<0.0001**
	Naples (IT)	15.35	13.27	10.55	<0.0001
	Madrid (SP)	9.13	8.16	9.23	0.8064
	Barcelona (SP)	5.35	5.23	6.24	0.5133
	Lisboa (PO)	8.65	8.13	6.37	0.0121
	Athens (GR)	9.62	8.49	7.86	0.0214
	Coimbra (PO)	5.62	6.10	4.27	<0.0001

Source: Source: Our Elaboration on Eurostat 2019 - 2022–

In Table 5, multiple regression analysis, there was no statistically significant difference in the two groups: medical and surgical patients. Among medical patients, the first condition (died) displayed in the case of "Full EHR vs no EHR" 0. 96, Odds Ratio (OR) 0.87 and Confidence Interval (CI) 1.0, R-value 0.4729, similar evaluation can be presented to "Partial EHR vs no EHR" with OR 0.9 and CI 1.1, R-value 0.9477.

Table 5. Association between Medical and Surgical Patient and EHR Implementation Status* - 2019/2022

Group	Condition	Full EHR vs no EHR OR (CI)	*R* value	Partial EHR vs no EHR Or (CI)	*R* value
Medical	Died	0.966 (0.87; 1.05)	0.4729	1.003 (0.93; 1.13)	0.9477
Medical	Emergency	0.971 (0.94; 1.04)	0.2748	0.985 (0.97;1.08)	0.8796
Medical	Planned	1.067 (0.88; 1.33)	0.7156	1.145 (0.95; 1.43)	0.2413
Surgical	Died	1.247 (0.97; 1.67)	0.1467	1.256 (0.96; 1.68)	0.1798
Surgical	Emergency	1.039 (0.97; 1.27)	0.5506	1.044 (0.96; 1.16)	0.5164
Surgical	Planned	1.233 (1.00; 1.53)	0.0454	1.113 (0.93; 1.33)	0.2687

Source: Source: Our Elaboration on Eurostat 2019 - 2022

*All models were elaborated for age, gender pay ticket, group, hospital size and hospital city; CI=confidence interval, EHR=electronic health record, OR=odds ratio, CI = 95%

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There are statistical differences between medical and surgical, "died" rates and *R-value*, both "Full EHR vs no EHR" and "Partial EHR vs no EHR". There are no statistically significant differences in emergency rates among surgical patients treated at hospitals with "Full versus no EHR" or partial versus no EHR. No statistically significant differences exist between rates and *R-value* in emergency conditions linked to "Full versus no EHR" or partial versus no EHR. Medical planned display between Full versus no EHR" or partial versus no EHR a difference of 0.78 with no relevant differences in terms of CO and CI. The same trend, with no relevant differences, is in the group surgical and planned condition. The differences between two groups and the same condition are not statistically relevant to Full versus no EHR" or partial versus no EHR. In Table 6, cities hospital and condition patients, the conditions that emerged are: day hospital and planned there are correlations with emergency. The "dead" condition, for obvious reasons, has not been assessed. The cities, display statistically significant, "Day Hospitals" for Naples (Italy), Madrid (Spain), Lisboa (Portugal) and "Planned" for Barcelona (Spain), Athens (Greece), Coimbra (Portugal).

Table 6. Association between Hospitals (Cities) and Condition Patient and EHR Implementation Status* - 2019/2022

Cities	Condition	Full EHR vs no EHR OR (CI)	R value	Partial EHR vs no EHR Or (CI)	R value
Napoli	Day Hospital	0.921 (0.82; 1.15)	0.4745	1.013 (0.83; 1.23)	0.94667
Bari	Day Hospital	0.951 (0.92; 1.14)	0.2784	0.975 (0.87;1.18)	0.8776
Reggio C.	Planned	1.027 (0.78; 1.03)	0.7177	1.175 (0.85; 1.33)	0.2423
Palermo	Planned	1.222 (0.87; 1.37)	0.1424	1.288 (0.86; 1.38)	0.1768
Potenza	Day Hospital	1.019 (0.87; 1.47)	0.5518	1.032 (0.86; 1.26)	0.5123
Cagliari	Planned	1.133 (1.00; 1.23)	0.0436	1.121 (0.83; 1.23)	0.2697

Source: Source: Our Elaboration on Eurostat 2019 - 2022
*All models were elaborated for age, gender pay ticket, group, hospital size and hospital city; CI=confidence interval, EHR=electronic health record, OR=odds ratio, CI = 95%

There is evidence of reduced risk of surgical patients in hospitals that had fully implemented EHRs from 2019 to 2022. These analyses found statistically significant evidence of an effect in only one case, Coimbra (Portugal), with "Full EHR vs no EHR". In all other cases (group, condition) and modality, "Full EHR vs no EHR" or "Partial EHR vs no EHR", there are no statistically significant correlations.

This study tested the level of EHR implementation in inpatient settings, surgical and medical patients, across 6 large and diverse cities in southern Europe. The results provided a preliminary foresee of EHR use. Cross-sectional analysis shows significant differences in mortality rates, in emergency and day hospitals, between patients with full EHR or partial EHR compared to hospitals without EHR. It is interesting to note that EHR adoption was not associated with improving quality delivery care. Notably, in the "Emergency" case, both surgical and medical, but also in "Planned" and "Day Hospital" conditions, there is no statistically significant correlation. The implementation status linked to the hospital (cities) highlights only in the city of Coimbra (Portugal) as statistically substantial evidence in the case of the "Planned" condition. This outcome has been reached in one year (2019-2020). Although EHR implementation is thought to improve the quality of service, this study, only in southern Europe, suggests that in their actual implementation, EHRs have yet to begin to reach targets and have a minor impact than expected on hospital organizations. A possible reason for this is that EHRs have very little to do with clinical aspects and that the use of data for mere reporting purposes has always prevailed in all areas. One example among many: is in the case of STEMI; CATAM; VEFI, but also in the other three cases, notifications of access and discharge are transmitted, and all post-discharge dressings are reported, but the anatomic-pathological report is rarely transmitted.
Furthermore, data suggests that technological solutions are possible and ready to use; probably, the health care organization, its modality to delivery service should be reorganized considering the opportunities that technology offers, in the awareness that these technologies represent a challenge in terms of change for the current

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organization of hospital medical work and service delivery. Our study has some limitations. The first concerns the geography area: only southern Europe, even if the 6 cities considered are metropolitan areas and regional capitals. In any case, the regional data of these cities collect the most significant number of patients. In addition, this study uses data to identify the level or adoption of the EHR, without assessing if external factors may facilitate the implementation of the EHR.

5. Discussion

The results highlight different useful points of knowledge accumulation and response to RQ. Understanding the relationship between ICT and EHR regarding sustainability and its implementation is a complex phenomenon divided into European Policy, Technological Innovation Trajectories, and Educational Investments points. The European Policy linked to sustainability and its implementation is related to the relationship between Information and Communication Technology (ICT) and Electronic Health Records (EHR). The GDPR sets (see 1.1 European contexts) out regulations for protecting personal data, including health data, within the EU. It establishes strict guidelines for collecting, storing, and processing health information, ensuring privacy and security in using EHRs. Compliance with GDPR requirements is crucial in implementing ICT-enabled healthcare systems, including EHRs, to protect patient confidentiality and promote trust. South Europe must pay more attention to interoperability and data exchange across European healthcare systems. South European countries, including Spain, Italy, Greece, and Portugal, have recognized the importance of seamless data sharing and collaboration among healthcare providers. Efforts are being made to establish common standards and protocols for EHR systems, enabling interoperability within and across borders.

The technological innovation trajectories linked to sustainability and its implementation are related to strengthening initiatives like the European eHealth Digital Service Infrastructure (eHDSI) based on cloud computing, which aims to facilitate cross-border health data exchange in South Europe. Cloud computing and data centres, utilizing cloud-based EHR systems and data centres, can enhance sustainability by reducing the need for on-site hardware infrastructure, minimizing energy consumption, and optimizing resource utilization. Cloud-based EHRs enable scalable and efficient data storage, backup, and retrieval while reducing the carbon footprint associated with traditional server-based systems. These initiatives are strongly linked to educational investments, the third point of sustainability and its implementation, allowing healthcare professionals to access patient data securely across different countries, ensuring continuity of care for patients who seek treatment or receive healthcare services in multiple European countries. Educational investments should focus on providing comprehensive training and skill development programs for healthcare professionals, administrators, and IT personnel. These programs should cover the technical aspects of EHR systems, data management, interoperability, privacy and security, and emerging ICT technologies. Ongoing education and professional development initiatives are essential to keep up with technological advancements and ensure EHR systems' sustainable implementation and utilization. These courses of action linked to the ICT process, which was started later than other Countries and overlapped other structural reforms of the government, made the southern European states recover in terms of service sustainability. The discrepancy between the provision of digital services and the unequal access to and diffusion of the European information society for patients to ensure communication with local hospitals.

Furthermore, South European countries increasingly implement national EHR systems and digital health platforms that promote interoperability. These platforms facilitate the integration of various healthcare information systems, including EHRs, laboratory systems, radiology systems, and prescription systems, to enable comprehensive and holistic patient care. In addition to improving patient care, the emphasis on ICT and EHR interoperability in South Europe also has the potential to support research collaborations and public health initiatives. Access to comprehensive and standardized health data can enhance epidemiological surveillance, facilitate clinical research, and enable evidence-based policymaking in Europe. Addressing these sustainability

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issues requires collaboration among healthcare providers, policymakers, technology vendors, and patients. Promoting standardization, data-sharing agreements, and privacy frameworks can enhance interoperability and data exchange. Investing in cyber security measures, privacy-enhancing technologies, and robust governance models can ensure the security and privacy of EHR data.

Additionally, long-term funding strategies, user-centric design principles, and environmental considerations can contribute to the sustainable implementation and use of EHR systems in the European context. Overall, the increasing focus on ICT and EHR interoperability in South Europe represents a significant novelty in the European healthcare landscape. It reflects a shared commitment to harnessing technology to improve healthcare outcomes, and its sustainability, enhance collaboration, and ensure seamless patient care across borders.

6. Conclusion

The research shows, according to European Union, the strategic function of EHR is to develop European ICT and its sustainability. Furthermore, the specific study developed in this paper highlights that EHRs adoption in European southern cities hospitals still needs to be a valid response to the challenge posed by ICT. On the one hand, it requires the development of a European information society, and it is necessary to achieve better service delivery and quality of service. In line with this statement, the European EHR is complex and debatable, particularly in southern Europe. It is interesting to note that, contrary to what was stated by the European Government reform law, applying the ICT and EHR method to southern Europe is very difficult. In this way, an accurate diagnosis of ICT in southern Europe is imperative to understand and implement sustainable solutions. The ICT and EHR are open questions, but it is necessary to execute sustainability actions; with this approach rapidly, it will be possible to improve the system and decisions related to the ICTs adoption in European southern cities hospitals.

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