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The LITIS conceptual framework: measuring eHealth readiness and adoption dynamics across the Healthcare Organizations

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Abstract The Italian Federation of Healthcare Trusts and Municipalities promoted a national initiative, named LITIS, on the levels of technological innovation in healthcare, to assist its members in the governance of the eHealth phenomenon. The result is a toolkit (i) to compare the policies among HealthCare Organizations (HCOs) within a jurisdiction; (ii) to help negotiate and monitor the balanced evolution of eHealth solutions within and across the HCOs, and (iii) to facilitate the collaboration among HCOs to face common topics. The primary achievement is a Conceptual Framework, spanning over the complete spectrum of the support to care and administrative processes, assuming two perspectives: the Functions F (services for citizens, social/healthcare professionals, managers, administrative staff) and the Enabling Components C (prerequisites to deploy the Functions and handle the change). The framework entails a taxonomy of indicators to assess the eHealth readiness and adoption in the HCOs: at first the raw data – from a survey that involved nearly two thirds of the Italian HCOs—were transformed to yield a lower layer of 145 micro-indicators, then the micro-indicators were aggregated at an intermediate layer for two different purposes, either as 36 topics or as 12 sectors; the upmost layer was made of 3 macro-area indexes and a global index, named "ICLI". The ontological structure behind the framework allows to adapt the set of micro-indicators to the context of any particular jurisdiction. The global index was used to classify each HCO into one out of five "Classes of Innovation" of increasing functional completeness. The lessons learned on presentation and interpretation of results are described.

Keywords eHealth readiness and adoption · Healthcare trusts · eHealth planning · eHealth roadmaps

1 Introduction

1.1 The evolving needs towards Connected Health

Among all the technologies in the healthcare milieu, eHealth systems and services deserve a relevant role, as they encompass "*the use of emerging information and communications technology, especially the Internet, to improve or enable health and healthcare*" [14].

This paper claims that suitable strategies are needed for a better governance of the phenomena related to the diffusion of the eHealth services; in fact, many complex dimensions are simultaneously involved. In the words of Eysenbach [17] and Pagliari et al. [35], eHealth concerns "*the organization and delivery of health services and information using the Internet and related technologies. In a broader sense, the term characterizes not only a technical development, but also a new way of working, an attitude, and a commitment for networked, global thinking, to improve health care locally, regionally, and worldwide by using information and communication technology*".

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In the vision of the European Commission [15] it "*means the use of modern information and communication technologies (ICT) in support of health and health-related fields, and to meet needs of citizens, patients, healthcare professionals, healthcare providers as well as policy makers. eHealth covers the interaction between citizens/patients and health-service providers, institution-to-institution transmission of data, or peer-to-peer communication between citizens/patients and/or health professionals*".

The planning of eHealth deployment in principle requires the definition of effective policies and the harmonization of the initiatives on eHealth innovation. In this respect a conceptual framework—with models, and tools for evaluating and ranking the levels of deployment within and across HCOs—could play an important role.

Actually, the accurate and timely information and expert support provided through eHealth enhances the capabilities of the healthcare professionals [47] and of the citizens, leading to the idea of "Connecting for Health" [32], "Health Connect" [4, 25], and "Connected Health" [33].

Far from being a mere change of name, the evolution of the term from "eHealth" to "Connected Health" represents the natural consequence of a new holistic perspective, whose primary focus doesn't lie on the technological solutions, but rather on individual's health in the most comprehensive sense [39, 41]: the various care organizations should "behave as a coherent system" [45], thanks also to the integration among all the information resources, designed and centered around the citizen.

The ongoing reorganization of care processes, especially the shift towards integrated care, as well as the increasing patient engagement about chronic diseases or frail and dependent subjects (i.e. with citizens becoming more responsible for their health status and lifestyles), asks for a *systemic* deployment of eHealth systems and services (e.g. [2, 6, 31, 43, 51]). In collaboration with a citizen and his/her caregivers, all the involved professionals—even working in different health and social care units—should be enabled to behave as a unitary functional "virtual facility" centered on that individual [41].

Driven by the need of an economically sustainable evolution of the sector, and according to the priorities of healthcare planning to accomplish the welfare priorities, each Health Care Organization (HCO) should therefore purposively develop a coherent continuum of interacting clinical, organizational and administrative components, aligned with the corporate strategies and consequent to the redesign of its own clinical and organizational processes.

The overall local evolution should be facilitated and coordinated at the level of wide jurisdictions, with a clear definition of the distribution of roles within the HCOs and with the respective authorities or eHealth-related consortia, for instance about common interoperable infrastructures for data exchange within and across jurisdictions.

1.2 Measuring the readiness and adoption of eHealth solutions

Usually the eHealth evolution among the diverse application areas and within each area seems to be largely spontaneous and poorly coordinated across the facilities. The orderly development of all the eHealth services should require a strong political and managerial support, to enable cultural and environmental changes with a deep involvement of all the stakeholders [46]; a great effort is therefore requested to develop suitable strategies towards a strong cooperation among the provider organizations and a better governance of care processes.

To achieve effective strategies, a model about the propagation of the technological innovation and an assessment methodology are needed. This propagation may be considered in principle according to various perspectives, e.g. in relation to the dynamics of diffusion, receptivity, adoption and sustainability [7, 20, 21, 52, 53]. The purposes—and thus the methodologies—of the assessments may be very different, depending on the context of the evaluation.

For example, the authorities of a region could aim at monitoring the e-government initiatives included in their action plans, as the infrastructures for the identification of citizens and health professionals, or the diffusion achieved about e-booking and e-prescribing. The authorities could instead be willing to compare the level of usage of ICT in the population, e.g. the access to the Internet by the citizens for health information or for health-related social networks. On the other side, the industry is interested in the size of the market for each ehealth sector and on the growth forecasts, including the administrative and managerial applications.

The perspective described in this paper is the one of the harmonization of the deployment plans among HCOs, namely the public Community and Hospital Trusts of a region; therefore the work was driven by the need to perform an effective governance of the eHealth phenomenon within a large jurisdiction.

In fact, the healthcare service provision of the Italian NHS is ruled by the Regional Authorities. In each region, healthcare is provided through two kinds of HCOs: (i) the Community Trusts (Aziende Sanitarie Locali) are responsible for primary, home and community care; they may also provide secondary care and often include inpatient services; (ii) Hospital Trusts (Aziende Ospedaliere) provide secondary care and specialized outpatient services to the other sectors. Social care is mostly in charge of Municipalities, although in some regions it is managed by the Community Trusts.

The main goal of the work was to allow a regional authority to orchestrate with its Trusts a step-wise action plan on the eHealth adoption, which should be at the same time: balanced across the territory, harmonious across the care sectors, uniform across the ehealth domains, and coherent among the applications within each domain.

For this reason, the approach described in this paper is not limited to a single category of care facilities (e.g. hospitals) or to a category of applications (e.g. usage of the Internet), or to a technological subdomain (e.g. management of multimedia documentation), or to a subset of actors (e.g. citizens or GPs). Our perspective includes in principle the complete spectrum of all the actors, health domains, facilities and technologies.

1.3 The LITIS initiative

In 2010 Federsanità-ANCI (the Italian Federation of Community and Hospital Trusts and of the Municipalities) promoted an initiative on national scale, named LITIS (Italian acronym for "Livelli di Innovazione Tecnologica In Sanità"), in order to produce and validate a toolkit for assessing the levels of technological innovation of its members, and to assist them in the harmonization of their planning efforts.

The activities were carried out in collaboration with the Department of Innovation of the Presidency of the Italian Council of Ministers and ForumPA—a major actor in the process of innovation of the Italian Public Administration—with the methodological support from the Italian National Research Council (CNR) and produced a survey on the level of technological innovation in the Italian Community and Hospital Trusts.

The present work provides an overview of the LITIS toolkit components, describing and discussing the research issues on: (i) the *conceptual framework*, which is the basis for the other tools and the questionnaire used in the Italian survey, (ii) a general pattern for defining a set of *basic micro-indicators* to measure the level of accomplishment of the eHealth dynamics, (iii) the *multi-layered taxonomy* for the stepwise aggregation of indicators up to the score of a global index, named "ICLI" (for "*Indice Composto del Livello di Innovazione"*), used to rank the Italian HCOs; (iv) a *data visualization dashboard*, the "Mosaic", applied to the Italian survey, together with the guidelines to interpret the results.

2 Materials and methods

2.1 The top-level model

The top-level model envisaged for the LITIS conceptual framework encompasses two complementary perspectives (Fig. 1):

- the Functions (F), meant as services of which different kinds of actors (citizens, social/healthcare operators, managers, administrative staff) can take advantage;
- the Enabling Components (C) that, though not providing direct services to the different actors, stand as the qualifying prerequisites to deploy the Functions and handle the change.

The Functions were categorized into three macro-areas, depending on the role played by the target users, namely *citizens/patients, healthcare professionals, and healthcare providers*, as mentioned in [15]:

- F1: Functions for citizens (including: healthy subjects, inpatients, outpatients, recipients of Long Term Care and informal carers), to facilitate their participation and access to the healthcare services;
- F2: Functions for healthcare professionals, related to prevention, assistance and care, which in turn was divided into three sub-categories:
  - F2a: Functions to support the care activities of a single healthcare professional or a team, including the systems of Electronic Medical Record (EMR) and Electronic Nursing Records;
  - F2b: Ancillary functions (e.g. prescriptions, laboratory reports, certificates, reimbursement claims);
  - F2c: Functions about the clinical collaboration among professionals of different facilities, including the systems about the shared Electronic Health Record (EHR).
- F3: Functions about healthcare management, logistics and administration and all the other functions not directly linked to care provision, e.g. for research and epidemiology.

The Enabling Components feature as well three macro-areas:

- C1: Basic technological infrastructures;
- C2: Application components;
- C3: Non-technological factors, including the structural provisions for the eHealth governance.

The C1 and C2 macro-areas refer to the technological prerequisites to support most of the functions.

The C3 macro-area concerns all the non-technological factors affecting the diffusion of the eHealth systems and services, including the policies and the regulations (with the initiatives to introduce the innovative organizational models), the financial issues and the economic incentives, the cultural situation (with the education of the citizens and the training of the professionals), the management of the eHealth workforce, and the structural readiness of each HCO towards an effective governance of the eHealth phenomenon. The components about eHealth governance were adapted from the panel of structural parameters elaborated for the Information Policy Unit of the English National Health Service (NHS), about the readiness towards the ICT innovation [37]: a study focused on the eHealth Local Implementation Strategies (LIS) arranged by the HCOs, within the campaign of adoption named "Information for Health".

In order to stress the functional approach of the LITIS framework and to limit the burden about data collection

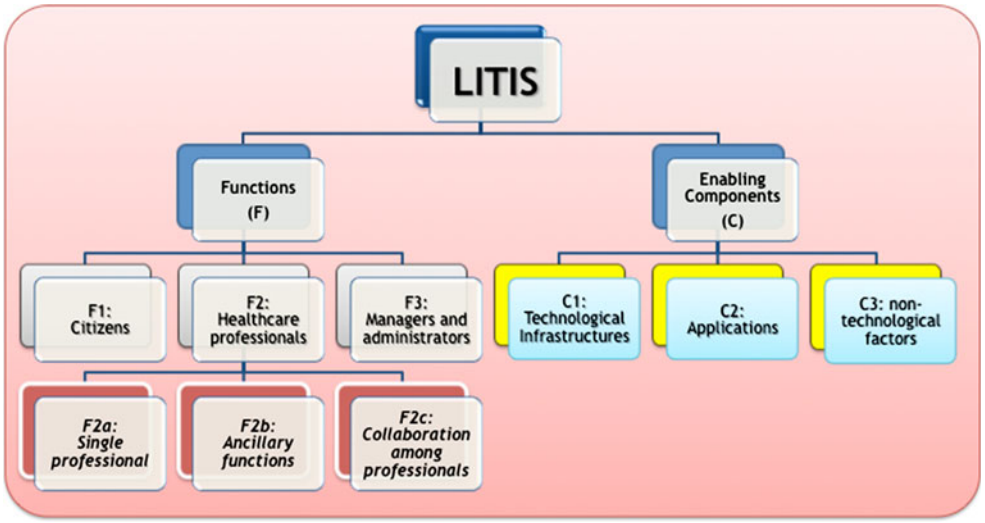

Fig. 1 The top-level model of the LITIS Conceptual Framework (see text)

within the Italian HCOs, the actual survey was focused on the F functions, with a few questions about the C3 sector, to allow the analysis of the potential relations between the current asset of the eHealth services and the arrangements on eHealth governance.

Most C1 and C2 technological components were not included, because several studies already covered the field and considering that, to be able to deliver the F functions, it is implicit that the related C1 and C2 components should have been in place.

2.2 The field survey

Starting from the top-level model, an interim list of functions was at first produced by the Authors, with the assistance of Federsanità-ANCI and ForumPA. This list encompassed the whole continuum of tasks performed by citizens, healthcare professionals and managers, as it enumerated a wide spectrum of potential activities within a HCO that can be supported by ICT solutions, together with the related enabling ICT components. The interim list was then discussed and validated by a panel of domain experts, mainly from HCOs and industries, so that an enhanced list of functions was produced. Subsequently, for each function a set of detailed questions was worked out into a questionnaire with quantitative and qualitative questions, initially tested on a small number of HCOs and then used in the survey within the Italian NHS.

The questionnaire was administered to all the Italian Trusts, through their CEOs; raw data were gathered from 64 Community Trusts and 83 Hospital Trusts. In these years regional authorities are gradually reorganizing and merging their Trusts and at the time of the data collection the total number of Trusts in Italy was about 230, thus the sample represents nearly two thirds of the Italian HCOs, covering the whole range of eHealth innovation levels.

2.3 Building the toolkit components

From the questionnaire schema produced for the initiative and from the analysis of the raw data collected it was possible to build 145 functional "micro-indicators" on eHealth readiness and adoption. Depending on the respective context, a specific algorithm was worked out for each micro-indicator, to calculate a numeric value by aggregating the values of one or more raw data elements. In addition, 20 micro-indicators were built for the Enabling Components in C3, to explore possible relations between the eHealth governance model of an HCO and its level of innovation.

The definitions of the micro-indicators have been refined through an ontological analysis, performed in order to produce a "Categorial Structure"—as defined by the CEN standard EN 12264 [9]—for their systematic representation, which will be described in Section 3.1.

The micro-indicators were then further aggregated at several levels according to different grouping criteria, up to the mentioned composite global index ICLI. The resulting multi-layered taxonomy is described in Section 3.2.

The taxonomy was afterward used in the design of a dashboard for the presentation of the data according to various perspectives. In fact, the survey was not only the experimental base to develop the ontology and the taxonomy on the micro-indicators, but also the opportunity to test diverse options for data processing and visualization on the results—used to produce the report by Federsanità-ANCI et al. [19] – and to verify the expressiveness of the indicators. Section 3.3 shows examples of the graphical presentation of the survey results and Section 3.4 describes how the results may be interpreted either to

discuss the ongoing situation or to set up a coordinated eHealth roadmap.

3 Results

3.1 The ontological analysis on the micro-indicators

The main goal of the production of a large set of micro-indicators was in the opportunity to get to a consistent and uniform layer containing the lowest-level numeric descriptors, able to decouple the raw data (with different qualitative and quantitative formats) from the issues of the optimal presentation in the dashboard. The organization and aggregation of the micro-indicators was carried out through an incremental and adaptive approach. An in-depth ontological analysis of the meaning of each micro-indicator was performed; a result has been the following set of rules for a *normalized representation* of their structured expressions (see the diagram in Fig. 2 and the examples in Table 1):

- each micro-indicator shall stem from an *action* (see the resulting list in Table 3 below) that is involved in the observation, which concerns a specific *actor role* (e.g. citizen, professional or manager);
- each action shall act on an *observable entity*, that is the entity to be considered for the measurements (e.g. activities, or documents, or persons);
- an *indicator algorithm* shall be applied, according to a *mood* (see Table 2), to each observable entity;
- if needed, one or more *topic details* may be specified to complete the accurate definition of the micro-indicator.

According to CEN EN 12264 [9], the systematic definition of each micro-indicator comes then unambiguously from the combination of the *mandatory* atomic concepts according to the Categorial Structure described above, plus any suitable topic detail where appropriate. Furthermore, each micro-indicator belongs to one of the mentioned macro-areas and has a three-digit ID (see Table 1).

More in particular, the admitted values for "mood", adopted after the analysis, are listed in Table 2 together with the algorithm typically able to produce the related micro-indicators.

The moods about *availability* (A*) express the level of technological readiness, while the moods about the *usage* (U*) are related to the level of adoption. According to the level of diffusion of the eHealth services in a jurisdiction, the design of the set of micro-indicators could be more oriented towards the readiness (mere availability of the technological components of the services) rather than to the adoption (actual degree of usage of the services); a gradual shift the set of indicators from readiness to adoption could be expected in the medium-long term. Depending on the mood, the typical result of an indicator algorithm may be a simple yes/no answer (*Y), an absolute number (*A), a percentage (*%), or a fraction (*M) to express the number of selected modalities out of a set of <n> predefined options. All these values were therefore normalized to yield a scale from 0 to 10, using an earmarked criterion for each micro-indicator.

In the present model, the "observable entities" corresponding to the moods expressed as percentages (i.e. A% or U%) resulted to be either a group of persons (e.g. citizens, GPs), or a kind of organizational units (e.g. diagnostic services, emergency departments, wards), or documents (e.g. administrative orders, electronic certificates, electronic prescriptions), or acts (e.g. payments, contacts).

As for the algorithms involving the count of the number of modalities (i.e. for the AM and UM moods), the predefined list of modalities was presented in the questionnaire, specifically for each micro-indicator. That list could enumerate e.g. kinds of diseases, procedures, information, eHealth services, or documents. In the examples of Table 1, the 7 modalities considered for the micro-indicator #004 were about the different kinds of useful information for the citizen available through the portal:

> [healthcare services and quality levels granted by the HCO; pathology-related patient rights; explanations on techniques and tools for medical procedures, treatments and tests; average waiting time to services; instructions before/after a procedure; addresses, maps, transportation; instructions to request healthcare services, equipments, refills].

Analogously, the 7 modalities for #091 were about different provisions to assist the collaboration on integrated

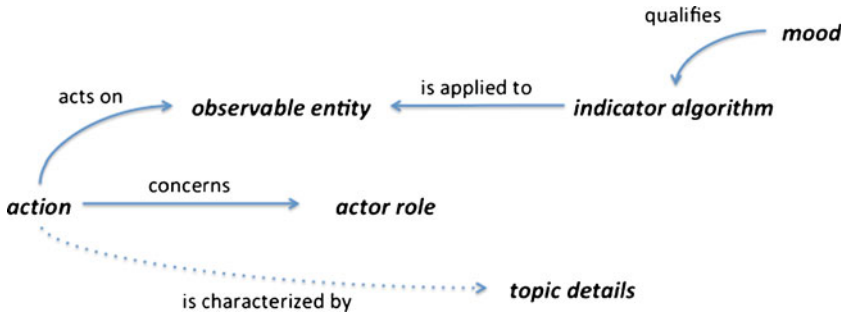

Fig. 2 The high-level Categorial Structure, i.e. the semantic pattern to systematically define a micro-indicator

Table 1 Examples of the structured representation of the micro-indicators

ID	Area	Action	Actor Role	Observable Entity	Indicator Algorithm	Mood	Topic Details
004	F1	to access practical information	citizens	available information	count over 7 modalities	AM	via portal/unidirectional
019	F1	to pay co-payment	citizens	co-payments	% over totalco-payments	U%	via web (portal or mobile devices)
054	F2c	to feed the intra-organization EHR repository	physicians	documents	% over total clinical documents	U%	according to the HL7-CDA2 standard
092	F2c	to support coordination with other professionals	care professionals	functions	count over 7 modalities	UM	disease management/via adoption of the same software
126	F3	to manage e-procurement	administrative staff	tenders	% over total tenders	U%	to handle results

management of the pathologies, for the professionals using the same software application:

> [adoption of predefined clinical data sets; notification of contacts and other relevant events; electronic communication; notification of care mandates; feeding data into a shared EHR; organizational support to functions as care manager; management of self-audit].

Table 3 shows the complete list of the actions worked out for each macro-area in the version of the LITIS micro-indicators described in this paper.

For each row the columns report the number of micro-indicators related to each mood. The amount of micro-indicators for each action, rather than being a sign of its relevance, actually reflects the different relevant perspectives that can be considered for a given action, in particular when various combinations of the additional topic details are involved.

3.2 The resulting taxonomy

The 145 functional micro-indicators have been iteratively aggregated according to different grouping criteria, to satisfy specific goals of the survey and to capture different dimensions of the analysis.

At the first level of aggregation, the 145 functional micro-indicators were clustered into 36 topics, which in turn were composed into 12 sector's indicators. More details on the overall stepwise procedure and the related data for the Italian survey are available in the LITIS report ([19], in Italian), or through the Authors.

Table 4 synthetically shows the resulting macro-indicators for the 12 functional sectors, together with the correspondent reference macro-areas.

At the upper level, a further aggregation yielded a cumulative index for each of the three macro-areas, ranging from 0 to 100. These three indexes eventually gave origin to the ICLI index, whose value—ranging as well from 0 to 100—summarizes in a single number the status of eHealth readiness and adoption for each HCO (Fig. 3).

Actually, according to their value of ICLI, each HCO was assigned to one of 5 "Classes of Innovation" (see Sections 3.3 and 3.4).

3.3 The analysis and the representation of the survey data

The survey offered the opportunity to gain experience in assessing the significance of the indicators and in intuitively representing and interpreting the results.

Table 2 List of the moods—with their typical indicator algorithms—used to produce the systematic representation of the LITIS micro-indicators

Code	Mood	Description	Typical Algorithm
AY	availability, yes/no	availability of the function within the organization	yes/no answer
AM	availability, modalities	fraction to express the number of modalities made potentially available, among the ones suggested by the questionnaire	count over <n> modalities
AA	availability, absolute	number of observable entities for which the function was made potentially available	number of <obs. entities>
A%	availability, percentage	percentage of observable entities potentially covered by the current state of deployment of the services	% over total <obs. entities>
UY	usage, yes/no	actual usage of the function within the organization	yes/no answer
UM	usage, modalities	fraction to express the number of modalities actually used, among the ones suggested by the questionnaire	count over <n> modalities
UA	usage, absolute	number of observable entities actually measured in the specified time period	number of <obs. entities>
U%	usage, percentage	percentage of observable entities for which the function is actually used	% over total <obs. entities >

Table 3 Number of micro-indicators for each action (organized by macro-area) and for each mood, as resulting in the experimental version of the LITIS model

Action	A%	AA	AM	AY	U%	UM	Total
F1 - citizen		4	12	7	8		31
to access clinical-healthcare knowledge		4	4				8
to access diagnostic reports				2			2
to access practical information			2		2		4
to book diagnostic procedures and outpatient visits			1				1
to manage administrative procedures			2		2		4
to pay co-payment			2		1		3
to receive support on the care process			1	5	2		8
F2a - individual professional	6	4	4		4		18
to access clinical-healthcare knowledge		4			4		8
to access the local EPR	4		4				8
to make local hardware and software available	2						2
F2b - operational procedures	4		5		14		23
to book diagnostic procedures and outpatient visits			1				1
to invite to screenings					3		3
to Issue medical certificates					2		2
to Issue prescriptions					4		4
to manage the drug delivery in the local pharmacies					1		1
to manage the intra-organization drug therapies	4		4				8
to receive support on the care process					2		2
to satisfy the orders of outpatient visits					2		2
F2c - cooperation among professionals	8		19	1	7	9	44
to access the intra-organization EHR repository	2		8				10
to feed the intra-organization EHR repository					3		3
to make Infrastructures available for inter-organization EHR				1	2		3
to make network Infrastructures available	6						6
to receive support on the care process					2		2
to support coordination with other professionals			11			9	20
F3 - management and administration			14	4	12		30
to handle delivery to warehouses					2		2
to handle moving from warehouses			7	4			11
to handle payments					3		3
to manage accounting			3				3
to manage e-procurement					5		5
to monitor quality and costs of services			4				4
to process orders					2		2
Total	18	8	54	12	44	9	*145*

The relevance of the indicators For each F micro-indicator, at least one HCO in our sample reached the maximum value of the scale, and usually the other HCOs are distributed through the whole range up to zero. It means that all the F micro-indicators resulted to be meaningful and sensible enough to categorize the HCOs; as expected, the corresponding functions, as defined in the questionnaire, are affordable today in our country and no function is already achieved everywhere.

About the C3 micro-indicators, a preliminary analysis of the relations with the F micro-indicators yielded no evident clues, suggesting that the recently enacted governance mechanisms in several HCOs were not yet able to influence the current local level of innovation.

The ICLI index is able to rank realistically the level of deployment of the eHealth functions among the HCOs; the maximum value registered for ICLI is 41.5/100, as no HCOs declared to have deployed all the functions, and only nine HCOs (corresponding to the 6.1 % of the sample) show a value exceeding 30/100.

The "Mosaic" dashboard Graphical techniques were used either to generate diagrams at different levels of aggregation

Table 4 The 12 functional sectors and the corresponding macro-areas, as used in [19]

#	Sector	Reference macro-area
1	Access to information about healthcare services, for the citizen	F1
2	Administrative streamlining and booking procedures	F1
3	Support to the citizen during care provision	F1
4	Handling information and knowledge for the professionals	F2a
5	Support to individual healthcare professionals	F2a
6	Dematerialization of prescriptions, medical reports, certificates	F2b
7	Dematerialization prearrangement	F2b
8	Support to cooperation during care provision	F2c
9	Diffusion of Electronic Healthcare Record (EHR) systems	F2c
10	EHR prerequisites (infrastructures and settlements)	F2c
11	Administration/Finance & Control	F3
12	Supplying and Logistics (Warehouses)	F3

(e.g. Fig. 4) in various versions ranging from the one covering synthetically the whole spectrum of the 36 topics to the ones exploded on a specific subset of micro-indicators about a particular topic, or to represent the geographical distribution of the dynamics concerning the diffusion of innovation of the HCOs (e.g. Fig. 5). In general, this data visualization approach resulted a means able to make extremely manifest the lack of common vision and know-how sharing across the country.

As an example of the dashboard for a detailed data visualization, Fig. 4 presents the "Mosaic", i.e. an overview of the level of innovation of the HCOs by means of the 12 intermediate indicators about the sectors introduced in Table 4. The range from 0 to 100 has been divided into five intervals; each interval has been associated in turn with a color (ascending order: black, red, yellow, green, blue), yielding a vivid representation. In this version, the rows feature the mentioned 12 sectors; the columns feature all the 147 HCOs involved in the survey, organized from left to right by decreasing ICLI values.

The figure shows that, within all the sectors, there are green and blue cells (high scores) even among the less computerized HCOs: this anomaly may be interpreted saying that the specific interest and know-how are actually present somewhere in the country, but disorderly spread out along all the classes and for almost any functionality. Similarly, black and red cells occur also for the most advanced HCOs: substantial room for improvement is therefore possible for them, too.

The Classes of Innovation and the geographical perspective As a different perspective, the above Fig. 5 shows the geographical distribution of the HCOs into the 5 Classes of Innovation along the five macro-regions of the country, where each Class has been assigned with a color (ascending order: black, red, yellow, green, blue). The chart gives a compact, quantitative assessment to a well-known situation in the Italian eHealth milieu; a non homogeneous scene can be recognized between northern and center-southern Regions: the formers are more advanced in terms of definition and implementation of paths of technological innovation, and about half of them appear among the two upper classes; almost three fourths of the latters stand instead in the two lower classes.

3.4 An example of interpretation of the Mosaic dashboard

The Mosaic (Fig. 4) is a tool aimed at providing the (national/regional) scenarios for local in-depth discussions, especially in the version based on the most detailed micro-indicators on a particular topic. In fact, it can be read in two main ways: one looking at each Functional macro-area, and one at the features of the HCOs within each Class of Innovation.

The interpretation about the functional macro-areas As an example of the first perspective, here is a possible interpretation along the horizontal bands of the Functional macro-areas in Fig. 4.

The F1 macro-area shows an overall moderate rate of diffusion of the direct services for the citizens (highlighted by a strong presence of red or black cells, but also several green or blue cells); some topics (e.g. the telemedicine services directly supporting the patient for care processes) appear still as underdeveloped, not representing yet a common (systemic) practice for patients' home care. Instead, as for the access to "useful information", especially via HCOs' web portals, a moderately slow adoption is registered, so that a wide range of services turns out to be still unavailable for the citizens.

As for the F2 macro-area (services for the professionals), a poor level of adoption is registered for most of the services linked to the access to clinical knowledge. In addition, the lack of connections (especially in clinical data sharing)

Fig. 3 The size of the multi-layered taxonomy of the LITIS functional indicators, as used in [19]

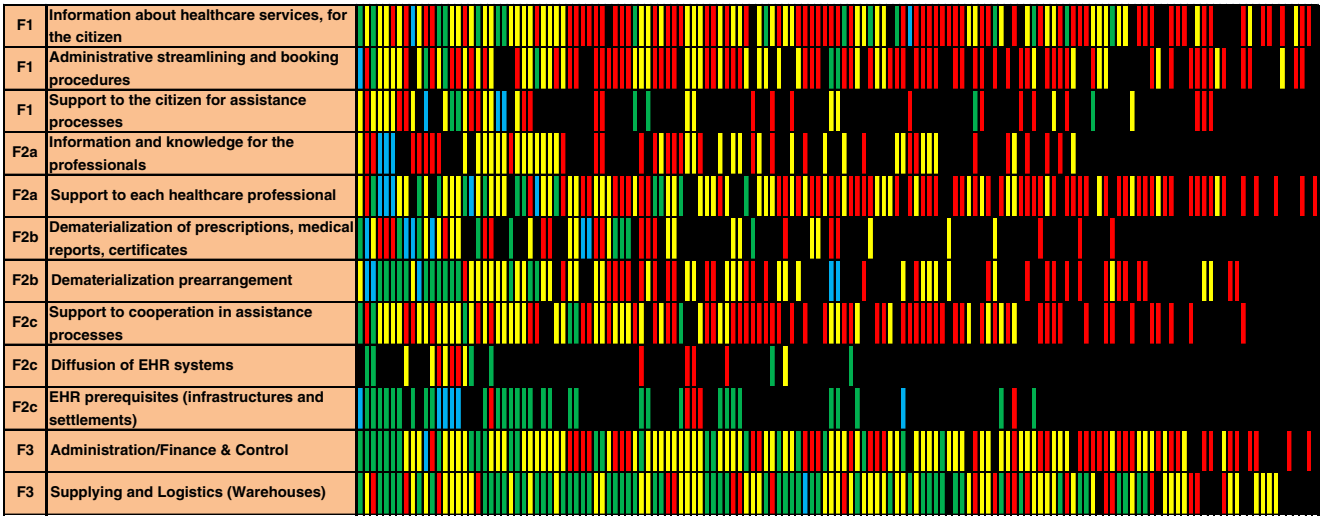

Fig. 4 The LITIS "Mosaic" in the version with 12 sectors; each column synthetically represents the status of a Trust (see text)

among healthcare operators hampers the coordination for performing integrated management plans. Moreover, it emerges that—besides isolated cases—most HCOs lack any advanced form of Electronic Health Record to integrate local clinical records in a single internet-based service, able to share citizen's clinical data, both during each single care episode or, more in general, during his/her lifetime.

The F3 macro-area (services for the management, including logistics and administration) shows instead a relatively wide deployment. In this sector, the efforts carried out towards the adoption are very clear, confirming that the awareness of the decision makers about the usefulness of ICT solutions in "their" sector is well established.

The interpretation about the Classes of Innovation Another way to read the Mosaic could be to consider "vertically" the set of contiguous columns for the HCOs that belong to the same Class of Innovation, to define the targets of the stepwise local evolution plans, perhaps with a common deployment of infrastructures. An informed discussion among the stakeholders within a jurisdiction could assist in scheduling the milestones to attain a sequence of increasing levels of adoption, *balanced across the various sectors*.

Class 1 (on the extreme right of Fig. 4) includes those HCOs where ICT exploitation is minimal, decisions are isolated and a true strategy is actually missing. Such organizations may be guided to identify and adopt those technologies that are already widely implemented in most HCOs, in order to reach a first milestone, i.e. to arrange the smallest, coherent backbone suitable for a subsequent gradual development plan; this requires the completion of basic infrastructures, such as intranet frameworks and internal electronic mailing systems plus a minimal set of well-established functions to be provided in each sector.

Class 2 features HCOs that already deploy the most basic ICT functions to cope with important issues concerning both business and care management. In the case of the Italian National Health System, they need anyway to be supported

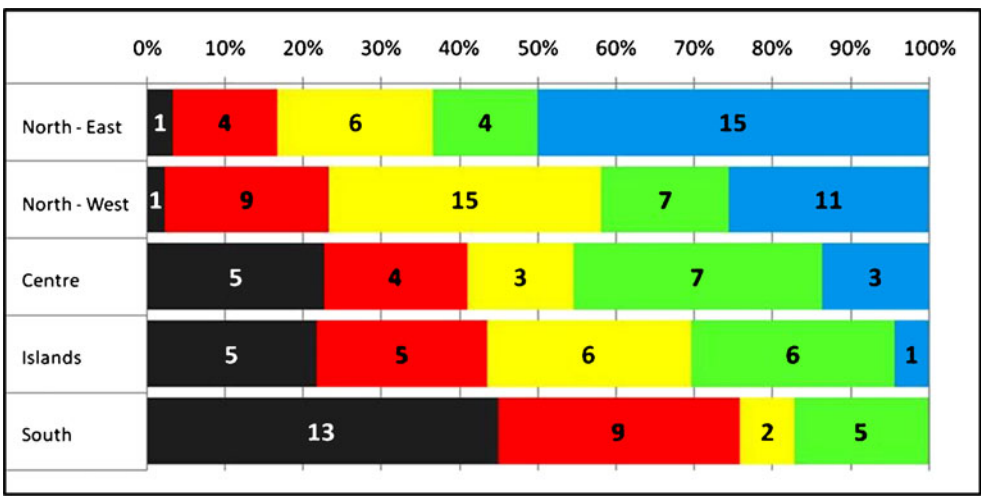

Fig. 5 Geographical distribution of the "Classes of Innovation" in Italy. The numbers represent the count of Healthcare Communities and Hospital Trusts within each Class in our sample

by central and regional institutions, to reach a second milestone, i.e. to complete a further block of basic functionalities, already proven to be stable and useful in the more advanced HCOs.

Class 3 contains the HCOs where appropriate functions are implemented not only for the business administration, but also for a significant management of clinical and organizational assets, featuring at least a partial integration among heterogeneous information subsystems. However, even if they deployed perhaps some advanced features, the missing overall design or strategy may cause these features to remain isolated and not coherent with other decisions. Nevertheless the achievements already done may make them able to support important organizational change, by activating or strengthening some meaningful clinical services (e.g., supporting integrated management, pathology networks, telemedicine), with positive outcomes on care processes.

Class 4 takes into account the HCOs where eHealth is more involved in the redefinition of healthcare processes and organizational models. Their features are similar to the ones from Class 3, but they reached higher scores thanks to a wider range of services provided and thus can target toward a more advanced milestone.

Class 5 consists of the HCOs on the extreme left of the Mosaic, which provide a reasonable number of advanced functions with respect to the current National context, even if some gaps still remain. The pioneering deployment of new functions in the jurisdiction could be distributed among these HCOs, with controlled experiments. A debate is needed, to clarify which of the missing functions are really worthwhile to be deployed, with respect to spend the resources to improve some already existing services.

4 Discussion

Section 4.1 elaborates on the change management in healthcare, which should be driven by policies on quality, sustainability and safety, with the eHealth support.

Then Section 4.2 compares the attitudes of previous studies on readiness and adoption in relation to the novel approach of LITIS.

Section 4.3 expands the perspective of the LITIS initiative, to face the needs of the HCOs about the governance on the eHealth phenomenon.

Section 4.4 considers the LITIS approach in the context of the Rogers' model of diffusion of the innovation.

Finally, Section 4.5 reports on the lessons learned in the study.

4.1 Governing the innovation in healthcare

The real innovation in the healthcare sector should originate from the rethinking of the care processes towards an improvement of the quality and the effectiveness, e.g. with the Chronic Care Model or the patient engagement [31, 42, 44]. As a consequence, the most effective technological innovation—involving the overlapping fields of medical devices, domotics, telemedicine and ICT—should be only a consequence of the introduction of the new organizational models [46].

In Italy and abroad, the healthcare system is not always capable of coping with an over-accelerated and "over-technological" approach to the eHealth topics. Achieving an effective alignment of the strategies, on a national and regional level, is strictly linked to the critical dynamics of interrelation existing between the main drivers of ICT penetration in the healthcare sector, namely: the e-government plans, the drift velocity within spontaneous markets, and the constraints introduced by healthcare planning (e.g. [42, 49, 50]). The lack of evident relations between C3 and F indicators—see Section 3.3—seems to confirm the difficulties regarding the governance on a balanced evolution of the eHealth sector; the topic should be further investigated.

Figure 5 adequately shows the phenomenon: it is the first consequence of the unbalanced growth of the ICT adoption dynamics in Italy, where regional evaluations prevail over a systematic national vision. In fact, in contrast to the national level, fully-fledged regional eHealth policies are in advanced stages of realization only in those few "Blue-labeled" regions, already effectively aimed at pursuing the three main strategic goals of the healthcare field: (i) high quality assistance processes and safer clinical decisions; (ii) supporting a sustainable evolution of the sector (i.e. high quality/low expenses); (iii) effective and appropriate access to the services for the citizen. Further in-depth examinations in single Regions are therefore expected for the next future of the LITIS endeavor.

The proactive participation of all the stakeholders to achieve a concerted and robust vision seems the best way to overcome the fragmentation and the lack of explicit strategies demonstrated in Fig. 4, as well the risk of a too centralized eHealth action plans, which may bring two main consequences:

- healthcare professionals may feel reluctant towards informatics solutions conflicting with the organization of care processes, showing scarce interest and cooperation, and providing incomplete and poor quality clinical data;
- HCOs may have a negative reaction towards the imposed innovation process, giving up any proactive behavior (especially for what concerns the care processes) and defusing the internal qualified personnel competences.

4.2 The goals of the assessment of readiness and adoption

Previous experiences are available in different countries, aimed at the assessment of eHealth readiness and adoption,

as connected to the HCOs status of technological innovation and the evaluation of their innovation capabilities; they cope with different, complementary aspects with respect to LITIS.

For instance, two eHealth benchmarking studies, recently commissioned by the DG Information Society and Media of the European Commission, are focused on specific professionals or healthcare settings. The former surveyed primary care physicians' use of ICT and the Internet for communication with patients and between primary and secondary care and other health agencies, in all the 27 Member States of the European Union and in Norway and Iceland [13]. The latter provides the result of a survey on benchmarking deployment of eHealth services in acute hospitals in 30 European countries; in that survey Chief Information Officers were asked about the availability of eHealth infrastructure and applications in their hospitals, whereas Medical Directors were asked about priority areas for investment, impacts and perceived barriers to the further deployment of eHealth [12].

As a different example of attitude, the survey by Orchard et al. [34] focuses on a specific disease (namely, cancer) and observes the information continuity in care processes within and across multiple settings. Funded by the Canadian Health Services Research Foundation and the Cancer Care Ontario, as part of the larger Cancer Services Integration (CSI) Survey, the research involves different types of care providers in a wide range of care settings, investigates on the providers actual access to the Electronic Healthcare Records (EHRs) of their own organization and of other organizations, as well as on the health record completeness, and examines the variation by provider type and location of work.

From the point of view of the EHR adoption, HIMSS Analytics [22] has developed a methodology and algorithms to score more than 5000 hospitals in US and Canada, relatively to their ICT-enabled clinical transformation status, to provide peer comparisons for hospital organizations as they strategize their path to a complete Electronic Medical Record (EMR) and participation in an EHR [29]. The collection and the analysis of the data are related to ICT processes and environments, products, Information System department composition, costs and management metrics, healthcare trends and purchasing decisions. The hospitals are then scored according to the EMR Adoption Model (EMRAM) that identifies the levels of EMR capabilities with 7 stages—plus a zero level—ranging from limited ancillary department systems up to a paperless EMR environment. Recently HIMSS Analytics Europe [23] produced a European adaptation for EMRAM.

Another systematic survey about the hospitals was the Ontario Hospital e-Health Adoption Survey (OHA), currently joined with the HIMSS Analytics initiative. The OHA and the Hospital eHealth Leadership Council have been gathering information since 2005 to assess the extent to which the hospitals in the Canadian province of Ontario are capturing, using and sharing health information through ICTs. Understanding where hospitals are today on eHealth adoption is valuable toward achieving the promise of eHealth, including the creation of a comprehensive Electronic Health Record [34].

Finally, the USA Meaningful Use developed a set of indicators to regulate the incentives on the adoption and use of health information technology (HIT), as a major priority for U.S. policy makers to cope with health care costs and improve quality. The American Recovery and Reinvestment Act (ARRA) authorized incentive payments through Medicare and Medicaid to providers that implement certified electronic health records and demonstrate their "meaningful use" [10, 24]. The U.S. Department of Health and Human Services (HHS) has stated a three-stage incentive program: Stage 1 is supposed to last up to the end of 2011; the accomplishment of Stage 2 and 3 is instead foreseen by the end of 2013 and 2015, respectively.

4.3 The LITIS perspective—measuring for planning

As for the Italian Public Health System, an effective allocation of responsibility for eHealth strategy development and their implementation collides with a complex scenario, where the presence of decentralized health systems, as well as of several ministries involved, points out the strong need for a concerted official, detailed eHealth strategy, with common goals that are agreed among all the different institutions [16].

Along with this, a number of surveys in Italy in the first decade of the XXI century have been already performed concerning the level of innovation in the Healthcare Organizations (e.g. Osiris project: [38]; OASI Reports: [8, 18, 30]). Their approach is normally market-oriented. Within the massive "E-Government 2012" Plan launched from the Ministry of Health and the Department for Digitalization and Innovation of the Public Administration from the Ministry of Innovation, a survey on the regional architectures for the longitudinal EHR was performed [11]. Nonetheless, the market of ICT penetration in the health sector in Italy is optimistically valuated at the present moment around the 1.5–2 % of the National Health Budget, and it is foreseen not to overcome the 2.5–3 % mark in the short-middle period [48].

The LITIS initiative is aiming at the overall goal of assisting a collaborative and balanced evolution of the eHealth sector, from the perspective of the Healthcare Provider Organizations in a large jurisdiction (namely the Healthcare Trusts and Municipalities of an Italian Region).

The support for the decision makers was therefore organized in two streams:

- a common, comprehensive Conceptual Framework about eHealth topics and issues, to facilitate the detailed negotiations with a collaborative intent between a regional authority and its HCOs, describing mutual roles and expected achievements. For each topic, the potential tasks of each stakeholder (Regions, Ministries, Municipalities, business management, social and healthcare professionals, information systems services providers, scientific societies, standardization organizations, service suppliers, and other actors) may be consensually defined in the context of that systematic framework.
- a toolkit, i.e. a methodology and the tools to assess over time the progress of each HCO towards explicit eHealth milestones by strategic action plans, in order to contribute in the evaluation of the impact of the different organizational and information solutions (both on the citizens and the healthcare system), and to compare appropriate short-medium term benchmarks across the different HCOs.

However, as far as eHealth is regarded, measuring readiness and adoption has a series of intrinsic and unavoidable complexities.

4.3.1 The various facets of the "readiness" and "adoption"

First, the readiness could be considered according to various technological and non-technological aspects, e.g. from a cultural [1], organizational [28] or policy-related [26, 27] point of view. To achieve a full adoption, all the readiness aspects should be satisfied.

A decision was taken in LITIS, to limit its focus on the technological readiness, i.e. on the set up of the infrastructures and the services that enable the effective usage of eHealth functions by the users. Moreover, the scope was not only about the care provision *sensu stricto*, but also on the other components of an information system, as the administrative and logistic management of the facilities and the practical services for citizens.

Second, both variables can be measured, qualitatively or quantitatively, in different ways: e.g. as absolute numbers or as a percentage of transactions (usually with respect to the whole spectrum of alternatives able to provide the service, including the electronic as well the traditional modalities). The focus of this assessment could regard either the coverage (e.g. in terms of care processes, facilities, or citizens) or the range of themes, procedures, issues that are involved.

Third, the same eHealth service may be deployed in several different ways, with a variable effect on effectiveness and robustness of the software, privacy, user satisfaction, friendliness, etc. Moreover, the integration among several existing sub-systems may present various degrees of efficacy, depending mainly on the usage of appropriate standard (e.g. clinical documents represented as HL7-CDA vs. plain XML vs. PDF). Only the knowledge about the vendor, the product, the release, and the customizations would allow to appreciate the real value of the particular implementation, but this overload of information will hamper the building of a comprehensive vision about the jurisdiction as a whole: these details can be collected as needed in a subsequent phase when priorities and actions are broadly defined.

4.3.2 Good practices and "what is missing"

For the above considerations the scope of the LITIS framework involves the whole range of potential eHealth functions (that is, not just the ones related e.g. to the broadband or to EHR systems) with an emphasis on the engagement of the citizens and on the primary care, especially for integrated management of chronic diseases and for healthy ageing, i.e. the major priorities for the healthcare policies.

The LITIS model analyses the overall spectrum of the potential usage of ICT in a HCO, and is aimed at measuring a nearly complete set of functions, according to the main purposes of the eHealth policies, namely: prearranging of enabling factors; improvement of the efficiency of the ancillary processes; management of care processes; supporting the healthcare system governance. Most indicators are on functions and processes, with less detail on the infrastructures (considered as a necessary prerequisite, implicitly satisfied for the delivered functions).

However, the primary goal of the LITIS initiative was not just to produce statistics, but to provide a systematic framework to facilitate the "live" interaction among the stakeholders: on one side, to enumerate the experiences and skills on each topic, on the other side—perhaps more important—to enumerate "what is missing" to obtain a balanced deployment of the services across the topics.

This systematic review could bring, in a jurisdiction, to the set up of a series of collaborative task forces to cope with a more uniform evolution on each eHealth topic, with precise milestones taking also into account the healthcare policies and the overall context. Hence, LITIS is not oriented as much to recognize the good practices on specific issues, but rather to guarantee an uniform and collaborative development for the whole eHealth field: in other words, it is aimed at ensuring that all the less reactive HCOs may reach at least the same minimum common level of innovation and that the most active HCOs may improve their services in a balanced way.

4.4 The LITIS approach in the light of the Rogers' diffusion model

According to Rogers [40], "Diffusion is the process by which an innovation is communicated through certain

channels over time among the members of a social system"; Berwick [5], moving from Rogers' research, reviewed a number of studies about the "spontaneous" diffusion of innovation in the healthcare field, defining five "behavior classes":

- *laggards*, which carefully assess pros and cons, before performing any change;
- *late majority*, i.e. the adopters that perform slow change dynamics;
- *early majority*, i.e. the adopters that quickly learn and adopt the innovation;
- *early adopters*, i.e. the opinion leaders that start the behavioral models, adopted later by the majority;
- *innovators*, which give origin to new solutions, but are rarely followed by the majority.

Many scholars (e.g. [3]) stressed on how the theory of diffusion of innovation helped to develop timely instruments through which eHealth promoters can get informed about how well an application connects with target audiences. Under this perspective, the LITIS approach applies well to the "on-off" adoption momentum of each particular innovation; instead the case of the eHealth framework as a whole results in a more complex phenomenon, where a large number of highly independent services are involved (with a different speed of diffusion), and each service can be deployed at different levels of effectiveness and quality.

The five Classes of Innovation described in Section 3.4—which assess the achievement of more or less high ICLI levels on the basis of a one-dimension numeric statistics—still appear very close to the ones described by Berwick. Nevertheless, it could be appropriate to develop more articulated criteria for each sector, in order to shift the focus towards a proper way to consider how far the HCOs address, accomplish and maintain a balanced deployment within and across the various sectors.

4.5 The lessons learned

This Section presents an assessment of the main lessons learned so far from the LITIS experience and its future perspectives.

Assessing and satisfying the local needs in a wide-area landscape The novelty of the eHealth phenomenon requires the development of a culture and tools for the decision makers, in order to envisage the optimal eHealth solutions corresponding to the change management initiatives deployed in the healthcare facilities. As a part of the LITIS initiative, Federsanità-ANCI activated a permanent board of CEOs of the Health Trusts, in order to face the challenge and to assist the decision makers about the harmonious evolution of the field.

The local eHealth planning should be synchronized among the HCOs and with the Regional Authorities. The evolution should orchestrate the level of innovation of the HCOs within each jurisdiction, suggesting a strategy based on a set of milestones, where each milestone involves a coherent and balanced block of functionalities that span over all the sectors. A large degree of optionality should be left to local decisions, to rank the relative importance of the functions within a predefined block according to local priorities, context and history.

To improve the interim classification of the HCOs based on ICLI, an enhanced mechanism with a set of explicit and validated criteria should be developed, both to decide the subset of micro-indicators suitable for assigning the HCOs to each Class and for correctly defining the threshold values to be satisfied.

The evolution and the customization of the micro-indicators Each aggregated indicator in the LITIS taxonomy is obtained by applying suitable weighted scores to a subset of micro-indicators. The total number and the quality of the micro-indicators in a particular jurisdiction depend on the context, i.e. they should be tuned with the healthcare policies and the ongoing status of innovation in the jurisdiction. To this end, the set of micro-indicators must be dynamic.

In fact, to be really effective as a planning tool, once the level of innovation increases the micro-indicators must be made progressively more sensible and refined in the further critical topics, and fade out about the topics that are becoming pervasive. The refinement of a micro-indicator may be obtained by various mechanisms, e.g.:

- by modifying the mood. For instance, in the Italian survey, the majority of micro-indicators was on availability, and no one was on the mood "usage-absolute" (UA); in the next years it could be expected a change from "availability, yes/no" (AY) to "availability, absolute" (AA), or an increase of the moods on usage (U*);
- by adding details to a micro-indicator to generate a subset of more specific ones, or by generating new micro-indicators on more specific aspects;
- by adding micro-indicators on the new topics that will become more important when the basic needs are going to be satisfied.

The overall coherence of all the potential micro-indicators could be supported by of the ontology presented in Section 3.1, provided that it evolves by an appropriate maintenance.

The flexibility of the taxonomy The same remark applies also to the indicators in the taxonomy: their selection and aggregation depend on the goals in the jurisdiction.

The taxonomy allows for different layers of aggregation, from the micro-indicators to ICLI; an intrinsic flexibility makes it possible to arrange the indicators of the same layer by manifold grouping criteria, depending from the specific issues to be analyzed to satisfy particular local needs. Of course, the slow drift of the micro-indicators and of the taxonomy implies a number of difficulties in comparisons over time, and the local adaptations of the indicators hamper a complete national and international comparison, which can be only limited to a small number of agreed stable indicators. However, the benefits on a more accurate planning within each jurisdiction are expected to compensate the above negative effects.

The future perspective Due to the novelty of the approach, LITIS is in an evolutionary stage. The current goal is not to measure the historical trends (which require a stable set of indicators), but to evaluate the usefulness of LITIS as planning tool and to make experience with the approach in real settings. The present indicators, their weighted aggregation and the criteria to assign HCOs to Classes are free to undergo future improvements according to the experience in their practical usage by the actors involved, in order to gradually achieve a more robust and generalized taxonomy.

Therefore, the next research and formative deployment cycles will be likely structured as follows:

- to check the potential usages and the effectiveness of the Conceptual Framework on a meaningful sample of HCOs, as a support to analysis, comparison, consensus-building, and planning;
- to implement local changes and/or integrations to the toolkit in a few jurisdictions, on the basis of the results of the previous step; draft a locally customized Conceptual Framework with the corresponding updated questionnaire;
- to study the local adaptations of the Conceptual Framework, to refine the taxonomy and harmonize the indicators, removing the unnecessary differences;
- to repeat the survey in a few jurisdictions, revise the current scores and weights to build the indicators and test the usability of the toolkit for actual planning purposes.

5 Conclusion

The first phase of the LITIS experience is now closed. The experimental data gathered from the national survey brought an overall vision on a set of generic methodological issues about the whole eHealth scenario and were used to envisage a broad-spectrum Conceptual Framework to measure and assess the levels of adoption of ICT solutions, for the governance of the "Connected Health" phenomenon described in the Section 1.1. The data were reasonably compatible with other sources and contributed to produce a better understanding of the eHealth phenomenon in Italy.

The emerging scenario points out that the Italian HCOs are predisposing themselves towards eHealth, according to the targets of the National e-government plans. The citizens—with increasing expectations—will soon ask for massive concrete outcomes, raising the need for local, regional and national comprehensive innovation strategies. It can be said therefore that, all conditions being equal, eHealth appears as very late for what concerns the deployment of policies of electronic communication with the citizen, if compared with other services typologies (e.g. mail, tourism, banking). Many innovation processes stem from the opportunities provided by the new technologies, but no corresponding "osmosis" processes took part between the professional figures involved (ICT, physicians, managers), not considering the scarce involvement of industry and citizens. In addition to this, a remarkable gap still exists in Italy between north regions (more advanced in terms of innovation strategies and policies) and center/south regions.

The HCOs can be assigned to Classes of Innovation; the lower classes are more focused in the deployment of the infrastructure, the upper classes could be able to use the eHealth services to support quality improvement in the care processes and the reorganization of care services needed to increase the economic sustainability of the healthcare system. In fact, the lower Classes of HCOs are induced to adopt a technology-driven attitude, i.e. to be focused on the deployment of some well-defined and "well-settled" operational services, by exploiting the opportunities provided by known effective solutions (e.g. e-booking, e-prescription); this approach provokes limited local perturbations in the organizational frameworks that can be adequately faced, but is not able to dramatically influence neither the care processes, nor the behavior of citizens and social/healthcare professionals on health promotion and maintenance. In other words, such approach doesn't affect the core business of the care system, i.e. the decision processes and the behaviors of the actors (professionals and citizens).

On the contrary, the upper Classes of HCOs may wish to adhere to a care-driven attitude, meant to address the needs of regional and national healthcare planning efforts, and to fulfill the requirements arising from the related targeted action programs. In fact, the adoption of currently available technological solutions can perhaps satisfy most of the information management requirements that descend from such action programs; nonetheless a coordinated and coherent demand dimension is needed, to provoke the necessary investments in the demand side to improve the level of adoption and thus within the industry to cope with the new requirements.

In this situation, achieving an optimal dimension of eHealth adoption to support changes in the organizational context requires its time. There are many issues to work out, in order to turn new ideas into practice (adoption); it is difficult to foresee the level of readiness—meant as propensity of people to embrace and use new technologies for accomplishing goals in home life and at work [36]—especially for what concerns the healthcare operators.

In their complex, the data coming form the LITIS initiative confirm that in Italy a general interest towards the Connected Health is high: in fact, there are spontaneously spreading functionalities (e.g. e-booking) and actions depending from government decision (i.e., support to screening campaigns); even if there are still potentially important functionalities that are not yet adequately developed (e.g. a structural adoption of telemedicine solutions).

This situation can be summarized saying that "not all the spontaneously developed topics are important, and not all the important topics are spontaneously developed". The LITIS toolkit may be useful to rationalize the evolutionary process of the eHealth deployment.

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