K4CARE: a new intelligent system for home care

D. Riaño[1], F. Campana[2], R. Annicchiarico[3], S. Ercolani[4], A. Federici[3] & P. Mecocci[4]

for the K4CARE Researchers.

[1] *Universitat Rovira i Virgili, Tarragona, Spain*

[2] *Centro Assistenza Domiciliare Azienda Sanitaria Locale RM B, Rome, Italia*

[3] *Fondazione Santa Lucia, Rome, Italia-*

[4] *Geriatric Dept. Univ. Perugia, Perugia, Italia*

***Abstract*—The K4CARE project (FP6-IST-4 IST-2004-026968) is a EC project about the development, integration and use of several Information and Communication Technologies (ICT) and intelligent Computer Science (CS) technologies in the framework of Home Care (HC). The main objective of the K4CARE project is to improve the capabilities of the new EU society to manage and respond to the needs of the increasing number of senior population requiring a personalized HC assistance. K4CARE will develop: a model for HC service which can be shared by the EU countries; an Electronic Home Care Record; a telematic and knowledge-based CS platform; a multi-agent system; Actor Profile Ontologies for representing the profiles of the subjects involved in the K4CARE model; Case Profile Ontologies for representing symptoms, diseases, syndromes; Formal Intervention Plans. The K4CARE project is developed by thirteen EU partners: eight centres with geriatric, medical and healthcare competencies and five ICT and CS centres**

I. Introduction

THE K4CARE – Knowledge-Based HomeCare eServices for an Ageing Europe – project [1] (FP6-IST-2004-026968) is a European Community project about the development, integration and use of several Information and Communication Technologies (ICT) and intelligent Computer Science (CS) technologies in the framework of Home Care (HC). Since no medical act can be appropriately performed without reliable information, appropriate sharing of patient's information and patient monitoring are basic pre-requisites in delivering effective continuous care in home care environments. K4CARE proposes a "patient focused" approach, designed to be translated to a pan-European level, with respect to the principles proposed by WHO to face the chronic diseases epidemic [2]. The use of KDD techniques connected to DSS based on existing guide lines (GL) and interacting with large databases of real patients (sources of evidence and knowledge), will develop a system of producing Evidence Based Practice (EBP) and Formal Intervention Plans (FIPs).

Manuscript received May 18, 2008.

II. Background

The elderly population needing full time care is considered as equivalent to the percentage of severely disabled elderly, which on turn is estimated to be 5% for the 65-69 year-old age group, 10% for the 70-79 age group, and 30% for the 80 and over age group [3] . This population can sum up to ten million people in the EU 25 area [4]. Age-related illnesses - and related dependency - require long-term care. As a result, there is an increase in the pressure on the public sector for long-term care. Hospitalisation – when not related to acute medical conditions, but to the need for rehabilitation or for social support – is both inappropriate and costly. The need of continuous care is not a matter for the "conventional" health system, but for the medical-social sector and specific measures will have to be taken. The factors related to how provision is organised are crucially important. In all probability, the only viable path is to assign the role of "small institutions of continuous care" to people's own homes, given the possibility to assure them the adequate structures and services. HC has been considered as a fundamental component of a network of long term care facilities (paralleled by rehabilitation units, nursing facilities). Preventive home visitation programs appear to be effective [5], reduce mortality and admission to long term institutional care [6], have a significant impact on hospitalization and are cost-effective [7]. Normative GL [8] can provide the mechanism to link patient outcomes to the care provided and improve quality without increasing costs. However, few GL have been developed for the homecare setting. Existing GL should be modified to be applicable in homecare [9]. Special issues in generating and modifying GL in home care patients are represented by co-morbidity and reliability of GL related to elderly patients [10] .

The typical HC Patient (HCP) is an elderly patient, with co-morbid conditions and diseases, cognitive and/or physical impairment, functional loss from multiple disabilities, impaired self-dependency. To this patient, it is not useful to apply a "vertical" approach, as to say, it is not effective to organize HC as a series of services focused on single diseases, but HC has to be carried out as a network of coordinated interventions: from a vertical

disease-related to a holistic function-related care.

III. PROJECT OBJECTIVES

The main objective of the K4CARE project is to improve the capabilities of the new EU society to manage and respond to the needs of the increasing number of senior population requiring a personalized HC assistance. The project will capture and integrate the information, skills, expertises, and experiences of specialised centres and professionals of several old and new EU countries, and will incorporate them in an intelligent web platform in order to provide e-services to health professionals, patients, and citizens in general. To achieve this goal, the members of the project will provide the scientific and technical knowledge, develop the intelligent technologies to manage that knowledge, supply the ICT infrastructure for anticipating and hastening the medical assistance, implement a web-based platform to approach these technologies to healthcare professionals, patients, and citizens, and assess the platform services in a scenario of combined old and new EU healthcare institutions. In particular, K4CARE is developing:

1. a model for HC service which can be shared by the EU countries. The model will indicate: the actors involved in the care of the patient (physicians, nurses, social workers, rehabilitative professionals, patient relatives, patients, and citizens in general); their professional liabilities; the services provided; procedures for the service performance and delivering; means, instruments, and modalities of multidimensional evaluation; method for organizing services accessory to the basic HC.

2. An electronic health record (EHCR), specifically designed and realized to be used in HC settings. This EHCR will integrate different data types (e.g. text, numerical values, multimedia parts) and documents coming from different sources (e.g. hospital services, laboratories, consultations, specialists, relatives and patients at home).

3. A telematic and knowledge-based CS platform that implements the above model. It will assist all the human actors involved in the care of HCPs. The platform will be tested on west and east EU societies through pilot tests in order to highlight their differences and also to pursue a convergence to a homogeneous way-of-doing, contributing to a unique European HC ICT approach. A multi-agent system will allow users to access the EHCR, edit, adapt, and merge ontologies, and introduce and induce FIPs and will provide e-services to care-givers, patients and citizens (e.g. scheduling of prolonged clinical treatments, intelligent decision support, intelligent distribution of data among users). Those services will be delivered through the Internet and the mobile telephony in a safe, everywhere, anytime way.

4. Actor Profile Ontologies (APO) for representing the profiles of the subjects involved in the K4CARE model: healthcare professionals, patients and relatives, citizens, and social organisms. APOs contain the skills, concerns, aspirations, etc. of the people that they represent, together with the healthcare services that those people offer to or receive from the K4CARE model.

5. Case Profile Ontologies (CPO) for representing symptoms, diseases, syndromes, case mix. Developed technologies for merging prototypic CPOs will be used to have CPOs adjusted to the individual condition of the patient.

6. Formal Intervention Plans for a number of diseases and syndromes. These FIPs will be generated from the information deriving from the available evidence-based guidelines. These FIPs will guide the services the system offers to the professional users. In other words, FIPs are the explicit expressions of how HC must be provided. FIPs will be inductively learned from the EHCR with the use of new machine learning techniques. These techniques must be developed and tested in the domain of HCPs. They are learned from the procedures regarding past patients stored in the system.

IV. THE K4CARE MODEL

In different European Countries, and in different areas of the same Countries, HC is structured in different ways, according to local rules, laws, and funding. The different prototypes reflect different approaches to HC, particularly referring to the kind of services provided, human resources organization and dependences. The K4CARE Model provides a paradigm easily adoptable in any of the EU countries to project an efficient model of HC.

The model proposes that the services be distributed by local health units and integrated with the social services of municipalities, and eventual other organizations of care or social support. It is aimed at providing the patient with the necessary sanitary and social support to be treated at home; the K4CARE Model is designed to give priority to the support of the HC patient (HCP), his relatives and Family Doctors as well. The K4CARE project recommends a modular structure that can be adapted to different local opportunities and needs. As shown above, the K4CARE Model is based on a nuclear structure which comprises the minimum number of common elements needed to provide a basic HC service: the Home Care Nuclear Structure (HCNS).

These elements are:

a) the actors involved;
b) the actions and liabilities of such actors;
c) the services available;
d) the procedures;
e) the documents.

The HCNS can be extended with an optional number of HC Accessory Services (HCAS) that can be modularly added to the nuclear structure. These services will respond to specialized care, specific needs, opportunities, means, etc. of either the users of the K4CARE Model or the health-care community where the model is applied . Each of the HC structures (i.e. HCNS and HCASs) consist of the same elements (actors, actions, services, procedures, documents).

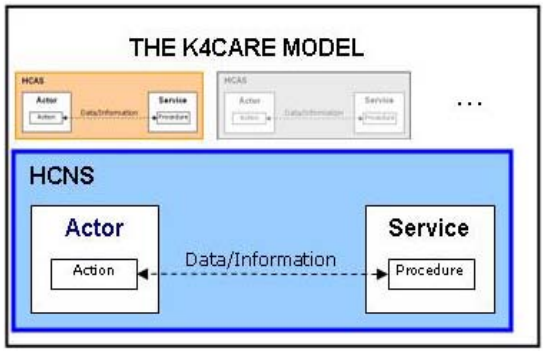

Fig. 1. The K4CARE Model.

a) the actors involved. Actors are the human figures included in the structure of HC: patients, relatives, physicians, social workers, nurses, rehabilitation professionals, informal care givers, citizens, social organisms, etc. In the HCNS, these individuals are structured in three different groups of actors: the patient ; the stable members of HCNS (the family doctor, the physician in charge of HC, the head nurse, the nurse, the social worker); the additional care givers. The family doctor, the physician in charge of HC, the head nurse, and the social worker join in a temporary structure – the Evaluation Unit (EU) – devoted to assess the patient's problems and needs. Other groups of professionals and non professional actors are usually part of the HC (Additional Care Givers: ACG). Their presence is almost ubiquitous, even if their position can hardly be comprised inside the core structure of HC. ACG do not have an exact and definite position in the context of the HC network, but their role results, in most case, fundamental for the continuous care of the HCP.

b) the actions and liabilities of such actors. A number of professional liabilities are linked to each of the profiles of the professionals included as Actors in the model; Professional Actions and Liabilities are the actions each actor performs to provide a service within the HC structure. Among these general actions, a certain amount correspond to those needed to perform the K4CARE Model services. The latter actions have been categorized and coded to be enclosed in the ICT platform.

c) the services available. Services are all the utilities provided by the HC structure for the care of the HCP. The HCNS provides a set of services, classified into Access services, Patient Care services, and Information services. Access services see the actors of the HCNS as elements of the K4CARE model and they address issues like patient's admission and discharge from the HC model. Patient Care services are the most complex services of the HC model, directly addressing the care of the patient. Finally, Information services cover the needs of information that the actors require in the K4CARE model.

d) the procedures. A procedure is the chain of events that leads an actor in performing actions to provide services. For each service, the sequence of actions constituting the procedure has been described. A special table links the actors involved in the procedure to the list of actions that configure the procedure of a particular service, and to the documents needed in that peculiar context.

e) the documents. Information documents are required and produced by the actors to provide services in the HC structure. The HCNS structure defines a set of information units whose main purpose is to provide information about the care processes realized by the actors to accomplish a service. Different types of actors will be supplied with specific information that will help them to carry out their duties in the K4CARE Model. All these data are considered to be part of documents. At the same time, those documents represent the basis of the Electronic Home Care Record, the electronic health care record specifically realized inside the K4CARE project

V. Project Description

In order to facilitate the care of senior patients at home, K4CARE will investigate and develop several IST data- and knowledge-based technologies and integrates them in a CS platform. The HCM will provide a description of the actors (i.e. professionals, patients, and citizens) involved in the care of senior citizens at home, the services a successful homecare system must provide, and the role that each actor plays in each service, integrating skills and particularities of several eastern and western EU countries. This model will be taken as the starting point both to analyse the data and information structures required by an EHR in the deployment of the HCM services, and also to represent, in a formal way, the knowledge which is beneath this homecare model. Two ontologies will be constructed: APO and CPO.

APO will gather all the relevant concepts and concept relationships to define actor profiles. CPO will comprise the concepts and the relationships to describe the most common pathologies in the care system (i.e. post-stroke, diabetic, cognitively impaired, or mobility impaired patients).

FIPs are formal structures to represent procedural knowledge about how to behave in front of a particular health problem. K4CARE will adopt already existing FIPs for those pathologies with agreed treatments, will develop new FIPs for unpublished treatments, and will apply machine learning techniques to generate FIPs from the information in the EHR about past treatments.

Finally, a multi-agent platform will be implemented to allow all the actors to interact in the HCM. On the one hand, each actor interaction will be constrained though actor profiles that will be adjusted by the combination and adaptation of APO concepts. On the other hand, the CPO and the FIPs will serve to tailor the know-what and the know-how knowledge on the target pathologies to the particularities of a concrete patient.

This platform will be tested by healthcare professionals, caregivers and patients in order to verify the adherence to their needs and duties, the possibility of use in every day activity, the capability of collecting and integrating information from different sources, and the possibility of use of computer management tools for personalizing FIPs.

The test will be performed by staff of healthcare providers in real home care facilities on western and eastern EU societies. The assessment of a second release of the platform - final product - will be performed in the community of the town of Pollenza (Italy) and will involve the entire home care facility, GPs, the Municipality, Social Assistants, citizens representatives.

VI. Conclusion

K4CARE will foster a direct impact in healthcare centres, healthcare national systems, and ultimately in the process of constructing a general homecare model in Europe. Whenever this last occurs, the HCM is expected to act as a reference to inspire the integrated use of the K4CARE proved successful ICT technologies to deal with homecare patients.

From a social and economic point of view, the K4CARE model will reduce homecare complexity and will make healthcare closer to the citizens in the sense that, information will be integrated in the HCP, its access will be more direct and safe with the use of ICT technologies, and the flow of information about the updated state of the patient among the different professionals will become time-space independent.

From a professional point of view, K4CARE final product will represent an intelligent decision support system in which personalized FIPs will help caregivers to provide each patient with the bestavailable personalised treatment.

The final EHR, the knowledge-base, and the CS platform will remain public at the end of the project for further uses and considerations.

The K4CARE project is developed by thirteen EU partners: eight centres with geriatric, medical and healthcare competencies (Centro Assistenza Domiciliare Azienda Sanitaria Locale RM B – Italy – medical management; Geriatric Department of University of Perugia – Italy; Ana Aslan International Academy of Aging – Romania; IRCCS Fondazione Santa Lucia – Italy; The Research Institute for the Care of the Elderly – UK; General University Hospital in Prague - Czech Republic; Szent Janos Hospital – Hungary; Amministrazione Comunale di Pollenza – Italy) and five ICT and CS centres (Universitat Rovira i Virgili – Spain – coordinator; Czech Technical University in Prague – Czech Republic – technical management; Telecom Italia S.p.A. – Italy; European Research and Project Office GmbH – Germany; Computer and Automation Research Institute of the Hungarian Academy of Sciences – MTA SZTAKI – Hungary). The project is a three year project with starting date on March, 1st 2006.

Acknowledgment

The Authors would like to acknowledge support from the EC funded project K4CARE: Knowledge-Based HomeCare eServices for an Ageing Europe (FP6-IST-4 IST-2004-026968). (http://www.k4care.net). The views expressed in this paper are not necessarily those of the K4CARE consortium..

References

[1] http://www.k4care.net

[2] WHO: *A strategy to prevent chronic disease in Europe. A focus on public health action. The CINDI vision*. Available at http://www.euro.who.int/CINDI/publications/20020322_3

[3] A Walker, T Maltby. *Ageing Europe* - 1997 - Buckingham; Philadelphia: Open University Press.

[4] http://epp.eurostat.cec.eu.int/portal/

[5] AE Stuck, M Egger , A Hammer, CE Minder, JC Beck. "Home visits to prevent nursing home admission and functional decline in elderly people: systematic review and meta-regression analysis". *JAMA* pp287(8), 2002.

[6] R Elkan, D Kendrick, M Dewey, M Hewitt, J Robinson, M Blair, D Williams, K Brummell. "Effectiveness of home based support for older people: systematic review and meta-analysis". *BMJ* 323(7315):719-25, 2001.

[7] F Landi, G Gambassi, R Pola , S Tabaccanti , T Cavinato , PU Carbonin, R Bernabei. "Impact of integrated home care services on hospital use". *J Am Geriatr Soc* 47(12):1430-4, 1999.

[8] AA Wilson. "Normative treatment guidelines in home care. Building the case". *Caring* 21(11): 24-7, 2002.

[9] LE Peterson . *J Healthc Qual*. 26(3):10-8, 2004.

[10] Heiat A, Gross CP, Krumholz HM. Representation of the elderly, women, and minorities in heart failure clinical trials. Arch Intern Med 2002;12-26;162(15):1682-8.