

Health in Smart Cities

Abstract—The goal of this white paper is to give a brief overview of the current challenges and trends in the field of healthcare with a view to a re-organization of cities in a smart direction. The main challenge is the development of innovative models supported by high-tech services for the prevention of frailty and disability in an aging society. Indeed, an hospital-based healthcare system as the only center for dealing with all the issues relative to health in a direct or indirect manner is inadequate to the peculiar needs of an increasing number of elderly people. This results in the need to build a network of highly integrated and continuous support services that can be implemented in differentiated assistance projects. In this context, the technology is playing an increasingly important role and an analysis is necessary regarding the sustainability and impact of the new health technologies on the existing scenery.

Keywords—Healthcare; smart city; wellbeing.

I. INTRODUCTION

Healthcare systems are going to face crucial challenges in the following years. First, aging of population: according to [1], the number of people in the world aged 60 years or over is projected to grow by 56%, from 901 million to 1.4 billion, and by 2050, the global population of older persons is projected to more than double its size in 2015, reaching nearly 2.1 billion. Projections indicate that in 2050 the number of people aged 80 years or over will be 434 million, having more than tripled since 2015, when there were 125 million people over age 80 (Fig. 1). This phenomenon is leading to an exponential growth of chronically ill persons with disabilities at motor and/or cognitive level, accompanied by a progressive lengthening of life expectancy in chronic conditions and disabilities. According to World Health Organization, chronic diseases are expected to increase to 57% by 2020. We are therefore seeing a rapid increase in demand for healthcare, while healthcare systems are dealing with depletion of resources. For these reasons, a major challenge is to ensure equity of access to healthcare services for everyone. There is therefore a need for low-cost and efficient solutions without compromising care.

In order to solve the growth of the healthcare spending due to the rising demand for long-term services and supports (LTSS) for people with chronic and disabling conditions, healthcare services are shifting to home and community-based settings (HCBS) [4]. These settings allow patients to receive health services in their own home and community. In this context, a key role is played by proactive medicine [5]. It includes programs for instituting lifestyle modifications and preventive measures able to identify chronic diseases early and decrease their impact upon the patient's life. This attitude reflects to a higher quality of life for patients and a cost reduction with respect to a reactive approach.

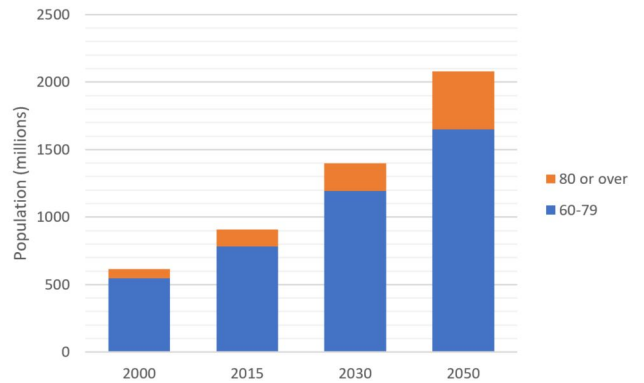


Fig. 1. World population aged 60-79 years and aged 80 years or over in 2000, 2015, 2030 and 2050 [2].

Patient empowerment can be a solution to the challenge of an increase need for care and help people live an healthy life [3]. People living with chronic conditions are becoming more informed, demanding and discerning especially for the quality of care and are requested to play a more active role in the decision-making processes regarding their health. Giving the right information and support, individuals and families can successfully monitor and manage chronic conditions, making life better for themselves and easier for the healthcare system. Often people living with chronic conditions are requested to change their lifestyles, such as diet and exercise. Healthcare system along with family, friends, fellow patients and the local community can be crucial in making lifestyle changes a success. Significant progress can be made by providing relevant information and treatments and by supporting people with chronic diseases in learning new tools to handle their everyday life. Dialog and partnership in healthcare between professionals and people living with chronic conditions can motivate to change things for the better, empowering individuals and the system alike. In the long term, patient empowerment is a good way to help people with chronic conditions take more responsibility for their own life and health. Some major changes have to be made for the empowerment to succeed. The healthcare system must create a patient-centered culture, in which patients are informed and involved in all phases of their treatment. People living with chronic diseases must be supported in making decisions regarding treatments. The job of the healthcare professional is to inspire, support and help, but not push. There are many ways to help and support and the challenge is to combine the best solution for each individual. In this way, the individual formulates his/her own goals, creating commitment and empowerment. Healthcare is

moving from a physician centric to a patient centric model and healthcare systems need to reorganize for a comprehensive patient care, where patients are at the center of their care path. Health and social care services have to be designed and delivered in an inclusive manner, enabling patients to take control of their health. It is therefore important that patients can understand their health conditions and participate in the decision-process with healthcare professionals. As healthcare professionals become better at supporting patients with making decisions and handling their chronic diseases, more professionals and more patients will feel empowered. Individuals with chronic conditions will experience that they themselves can take actions that will give them not only a longer but also a better life.

In the context of patient centric models, technology is changing the way people access and receive care. Devices such as computers, smartphone, TVs and wearable devices [6] enable a greater patient engagement in the management of their own care and enhance the coordination with caregivers and health professionals, regardless of their physical location and whenever needed. Technology can be used in the fields of prevention, diagnosis, treatment and monitoring. For example, in the field of prevention, technology can be useful for promoting a healthy lifestyle or slow down the incidence of age-related illness. There is a wide variety of apps that can provide exercises and recipes that promote physical well-being, help for stopping smoking or reduce alcohol consumption. There are also devices able to monitor physical activity, hours of sleep and calorie intake. In the field of diagnosis, new technological tools simplify the communication among healthcare professionals, allowing an immediate consultation of diagnostic data. During the treatment phase, in emergencies or particular clinical cases, new technologies can help rural medical clinics to communicate with specialized teams of the most central healthcare facilities. New technologies are also useful in the field of disease monitoring, thanks to the services made possible by new wearable gadgets (Fig. 2).

II. PROMOTING HEALTH AND WELLBEING

In this section, a brief overview regarding strategies for building an inclusive community for promoting health and wellbeing is given. As stated in [7], a “smart community” is “a community in which government, business, and residents understand the potential of information technology, and make a conscious decision to use that technology to transform life and work in their region in significant and positive ways”. In the field of health, this concept can be translated to structures, processes and social behaviors that act to improve health of community and wellbeing. Health systems have to assure dignity, autonomy and independence for longer time to frail and aging citizens. Indicators of “smartness” in health are quality of life, access to high quality healthcare services, remote healthcare monitoring and home automation to improve autonomy. It is important to develop a citizen-centered innovation system, in which citizens play an active role. They have

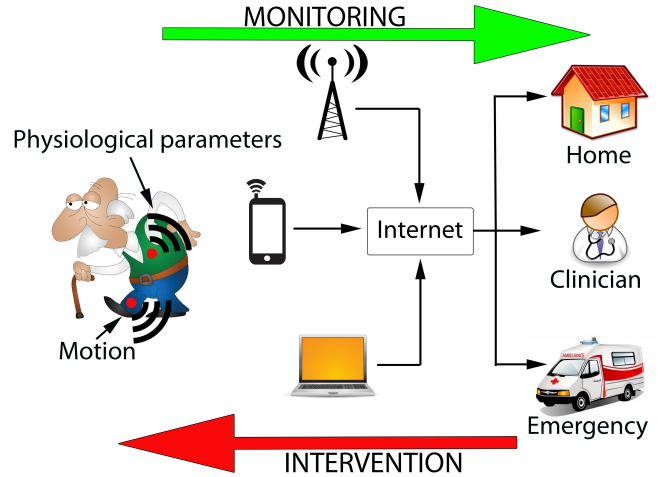


Fig. 2. The potential given by technology for health monitoring, ensuring emergency services regardless physical location [6].

to be aware of services they have the right to expect, having a simple interaction even with complex structures.

A first step is to align the health system to the new age-related challenges, developing and ensuring access to services for older people and training an appropriate health workforce. There is the need to develop long-term care services, ensuring quality and improving autonomy of patients. To achieve these goals, it is important to develop measurement, monitoring and understanding on healthy ageing, relying on agreed metrics and using analytical approaches.

A key factor for assuring autonomy and dignity to frail individuals is their home environment. In this context, ICTs can play an important role providing new forms for communication and interaction and developing new assistive tools. The proper use of ICT in this context can significantly contribute to reduction of costs and increase efficiency. An example is the concept of Ambient Assisted Living (AAL) [8]: a digital environment with a pervasive and unobtrusive intelligence able to proactively support people in their daily lives. The basic idea under the concept of AAL is the development and use of new technologies to enable elderly and disabled people to live comfortably in their home. The aim is to improve their autonomy, facilitating daily activities, ensuring safety, monitoring and treating people with specific demands. The widespread use of AAL may in many cases prevent hospitalization, allowing better quality of life and saving for the community.

Connected to the concept of AAL, in [9] an innovative project is presented, in which a domotic apartment inside a hospital structure was designed. Such apartment is equipped with a highly technological infrastructure that allows to monitor and assist the patient during the hospitalization. The philosophy of “living lab” is experienced: the patient lives for a certain period in this environment and his/her daily activities are monitored by an integrated system. The patient can test various care solutions and the therapists can validate

the effectiveness of the introduced aids, comparing past and subsequent data. In this manner, it is possible to introduce only the aids that actually improve the subject's quality of life.

The disciplines involved in this project are:

- smart architecture: environmental solutions, furnishings and objects designed according to ergonomic principles to meet the needs of different categories of users;
- ambient intelligence: innovative cognitive environments, capable of supporting a secure, well-equipped and monitored space.
- physiological status monitoring: sensors to measure the main vital signs and physiological parameters, able to give a better understanding of the interaction among the patients, the environment and the assistive tools. This sensors can give also information about reactions and mood of patients;
- innovative interfaces: the aim is to provide a more natural interaction of users with the smart environment, enhancing usability and acceptability of the technological assistive tools;
- inclusion: studying solutions not only able to passively satisfy the user's needs, but also to promote an healthy and active life-style. The aim is to support daily activities, communication, rehabilitation and social involvement.
- safety and monitoring: systems for the automatic analysis of the proper use of assistive tools, sensors for the user's safety, such as fall-prevention sensors, and tools for the evaluation of adaptation and customization of the assistive solutions.
- user-based assessment: definition of metrics and objective measurements of user satisfaction in the use of technologies and the effectiveness of the proposed solutions.

III. HEALTHCARE INNOVATION

In the current years, there has been a shift to a patient-centered care approach and the interest in health in the population is growing. The increase in technology is transforming the entire healthcare industry, which has to reassess its business models. Wearable sensors and systems are gaining an ever growing interest both from consumers and from companies. Smart wearable system (SWS) applications are emerging in the sport, entertainment, healthcare and military domains and lately there have been great improvements in terms of miniaturization, seamless integration, data processing and communication. Wearable tracking devices are improving patient engagement: more and more people are using these devices to monitor their physical activity, sleep patterns, calorie consumption, and other parameters. Such devices have the potential to give to healthcare providers real world assessments of their patients' daily life at a time when we are seeing a transition of care outside hospitals, due to increasing chronic diseases. However, there are some critical challenges in the use of these devices, such as limited battery life, invasiveness, privacy concerns, clinical validation and standardization.

Social media are offering a great opportunity to improve information and support from healthcare entities. Furthermore,

we are seeing an increase in data demands by clinicians and administrative leaders to optimize patient care. Data sharing could bring innovation and a better communication among healthcare services: the analysis of such data can allow to identify common health needs and help to create innovative solutions. In this context, particular attention must be paid to privacy concerns and data security, avoiding a misuse of private health data.

In the design process of new technologies and services, the user gained a central role in the last years. The user-centered approach allowed to develop systems that better matched users' needs, improving the user experience. In this kind of approach, the focus is on the product or service being designed and the aim is to ensure that the users' requirements are fulfilled. In the user-centered approach, the design of the product is conducted by researchers and professionals and the user's needs are investigated through interviews, researches and observations. In the current years, we are seeing a shift toward a participatory design approach, in which the attitude changes from design for users to design with users [10]. In this new approach, the user is asked to participate proactively in the design development processes, taking an active role in the group of stakeholders. As stated in [11], the relation between clinicians and patients is changing. The patient is becoming an active partner that wants to be involved and have an influence on his/her treatment and care. Participatory design in the field of healthcare allows achieving more effective services and sustainable programs, improving user's satisfaction.

IV. DIGITIZE HEALTH

Digital technologies are a central tool for addressing new care format and digitization offers an enormous amount of data, exploitable to improve diagnosis and treatment. Main advantages are better use of time and resources, improvement of patient's experience and a smarter healthcare system. One of the principal component in this field is eHealth (i.e. digital health), a term that encompasses the set of resources, solutions and information technologies applied to healthcare, including several processes and services, such as electronic health record (EHR) and telemedicine. The term EHR refers to the systematic collection of healthcare information of a person or a population in digital format, such as demographic data, medical history, medical treatments, allergy lists, laboratory test results and radiology images. The main benefits of EHR are [12]:

- enhanced overall patient care;
- accessed patient chart remotely;
- alerted to critical lab value;
- alerted to potential medication errors;
- reduction of duplicated lab analysis;
- increased capabilities to monitor chronic conditions.

On the contrary, the main drawbacks are related to limited interoperability, privacy issues and limited resources for the management of the EHR.

Technologies are improving care collaboration: cloud computing [13] and social media [14] are moving healthcare in a

social dimension, in which the patient is inserted in a network and actively participate to the definition and the management of the care path. In this context, given opportunities are the personalization of healthcare and the promotion of self-care management and healthier lifestyle. However, the other side of the coin is the risk of poor quality information, issues related to patient's privacy and the violation of boundaries between patient and professional. Indeed, it is important to underline that a cautious approach is necessary to manage data and information on network, since they are not a priori certified. Furthermore, availability and accessibility are not homogeneous and it is important to protect sensible personal information.

Cloud computing is a technology that enable, through remote servers, access to hardware and software resources (e.g., computer networks, servers, storage, applications and services), the use of which is offered as a service by a provider. Benefits that cloud computing could bring in the field of healthcare are the possibility to easily archive and use patient records and medical images. Moreover, cloud computing makes easier the team collaboration, allowing better communication at distance. The information becomes accessible from various locations and it is possible to minimize in-house storage needs. Another opportunity offered by cloud computing is data analytics with applications in medical research and for a more personalized and precise care. To enhance the benefits given by these technologies, interoperability is of paramount importance, because it allows data to be exchanged and shared across clinicians, patients, hospitals and research centers regardless of systems and devices used.

ICT technologies help to eliminate distance and may allow access to medical services, otherwise unaccessible to distant rural communities. One of the results is telemedicine, that is the use of telecommunication and information technology in order to provide clinical healthcare at a distance. Mobile technology can allow healthcare professionals to share information and discuss patient issues as if they were in the same place. Moreover, remote patient monitoring can reduce outpatient visits and enable remote prescription verification and drug administration oversight. All of this could result in a reduction of costs for the healthcare system. The drawbacks are the necessity to have specialized staff in the use of technology and the risk to decrease the human interaction between patients and medical professionals.

Internet of things (IoT) made possible the connection between object and people. The connection with the network allows object to take a proactive role and enable new possibilities for detection, remote control and monitoring. Example of applications in healthcare are the management of medical devices, i.e. precise location of the devices, state of use, level of obsolescence, maintenance status and functional verification. Moreover, Internet-connected devices can help to reduce the need for direct patient-clinician interaction and the caregivers can focus better their effort: for example IoT technology can be used to track health information, such as electrocardiograms, body temperature or blood glucose level.

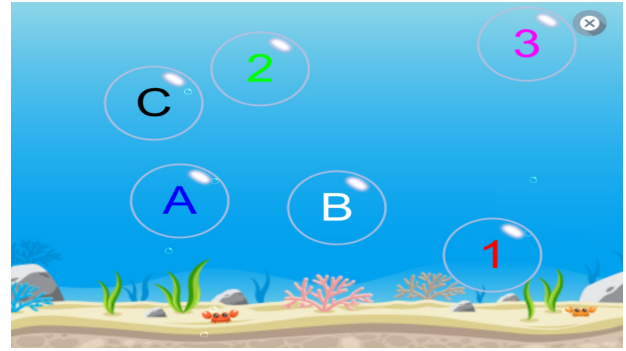


Fig. 3. A serious game example in which the patient has to “burst the bubbles” in the correct sequence. This game was developed by the Measurement, Instrumentation and Robotics (MIRo) lab of the University of Trento.

These technologies facilitate also the replica of the hospital environment in patient's home.

New technologies such as virtual, augmented reality and serious game applications (Fig. 3) find increasing expressions in healthcare. Examples of applications are in medical simulation, telemedicine, medical and healthcare training, pain control, visualization aid for surgery, rehabilitation and promotion of healthy life styles. Beside the use of virtual reality, the modeling of biological phenomena is widely used as an aid for better understand disease, interaction and plan possible interventions.

V. CONCLUSION

Information and communication technologies play an important role in facing the current health challenges and trends. In the context of a smart city, a key element is the promotion of an inclusive community for health and wellbeing, creating an ecosystem that involves citizens, professionals, private companies and public bodies for the definition and implementation of new services. One of the main challenges in a society, that is seeing an increasing component of the elderly part, is the prevention and early detection of frailty, acting in a proactive manner. Another important point is how to manage frailty and improve the independence and dignity of frail people. One of the possible answers is given by AAL, an environment that is able to allow the patient to live at his/her home in a safer and healthier manner.

Digitize health is a key factor for improving healthcare. Digital data and telemedicine services can reduce distances, allowing to contact specialists that are several kilometers away. Remote diagnosis and medicine make easier to share information, improving a truly personalized care. In this context, special care must be taken to guarantee privacy and property of personal data.

A smart city has a duty to continuously invest in research and innovation in the field of healthcare. Indeed, one of the central aim of the concept of smart city is to improve the quality of life of its citizens and, certainly, healthcare has a great impact on it.

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