Medical ICT Serving Society

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***Abstract*—This paper gives sights of future wireless healthcare and an overview of an innovation process targeted for novel medical ICT (information and communication technology) applications. The background of the topic is based on the development work towards an innovation centre focusing on combining technological and medical research at Oulu region in Finland. Though the paper is focusing on medical ICT, the reported issues are generic, and they can be adopted in wider scope. The innovation process is presented as circular separating from the typical linear model. Different players involved in the process can participate in different phases, and the starting point of the whole innovation process can vary. However, the driving force is the actual needs from the end-users' side.**

Keywords–innovation; prevention; health care, process; wireless;

I. INTRODUCTION

Medical sector has many times been seen as an isolated block which has its own language and mode of actions. Joint work between medical people and people from other expertise areas, such as engineering or marketing, is still limited. Encouraging discussion and co-operation between these different players is one way to fight against increasing costs and care needs which we are facing in the very near future. The pressure comes from the global demographic forecast which shows rapid change towards aging population. One activity within this context in Oulu region in Finland was a plan to create a new innovation centre that is focusing on merging healthcare, medicine, biotechnology and technology researchers in a wide scope. We are talking about research on medical ICT (information and communication technology) in which the targeted applications are for medicine, healthcare and welfare, but also for physical exercise and training.

The Oulu region, known from its strong mobile technology research and development since 1980's, includes multidiscipline players from academia but also from industry and public sector. This gives great opportunities to establish new working procedures and actions, firstly between the regional players, but eventually internationally. The major idea is to put these people having different backgrounds and fields of know-how to work closely in same projects by bringing their own special expertise for the common good. Adapting novel innovation processes is one option to implement new procedures and co-operation manners in reality. By creating something new that has own reflections to medicine, engineering and service sector will be a fruitful field to launch joint work amongst several institutions and introducing remission for healthcare processes in general.

In the last decades, the focus in healthcare sector has been on the medical treatment, consequently, after the clinical diagnosis has been made. Nowadays, the pressure has been moved more and more to prevention of diseases and for promoting the healthy lifestyle. It means that the possible medical problems will be predicted, and the individuals' manners of living are attempted to be changed before something negative happens in their health condition. The other issue is to support peoples' living at their own homes instead of being in institutional caring units, such as hospitals or elderly homes. The costs for society are much lower if people can take care of themselves at home. This needs advanced, easy to use, and robust technologies for self diagnostic, analysis and data communication between the person and nursing staff.

This paper is organized as follows. Section II gives an introduction on our views on future healthcare processes, Section III summaries some existing problems in healthcare sector, Section IV describes the circular innovation process, Section V gives some ideas for future medical ICT, and finally, Section VI concludes the paper.

II. FUTURE TRENDS IN HEALHTCARE

The previous studies CWC has carried out in the medical ICT field pointed out some existing problems in the current working procedures. For example, typical bottlenecks such as double writing, long waiting times, lost instruments and lack of all the necessary medical information in situ have been seen problems by the nursing stuff [1]. Double writing, for example,

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can be avoided if the measured data is transferred automatically to the electronic data bases instead of two phase process; first writing the values to notebook and afterwards updating the electrical database. In addition to the delay when the most recent data is available for use, there is an extra source for error if the information is handled twice. The use of wireless technology makes it possible to instantaneously update electronic records, even automatically. Moreover, existing wireless positioning solutions can provide tools to locate stuff or expensive instruments inside a hospital, or in a wider region indeed.

Locating patients inside a hospital is also good help to improve the existing processes. The staff is aware when a certain patient arrives, for example, to a laboratory, or is close to it. This information can be used to reduce queuing, or helping to start preparations of coming actions. All this can be done, if the patient is attached with cheap, disposable tag after registering to a hospital. The other simple example is real time phase information from the operating theater. The phase information includes in, e.g., the communiqué of an ongoing surgery, cleaning or fitting up the room for following action. The preliminary work at different wards can then be started in a synchronized manner, and the spare time of the special rooms can be minimized [1].

Wireless data transmission has also been seen valuable when transferring patients between wards or during the transportation to hospital [1]. After attaching medical sensors to body, the data is available all the time even if the patient is not close to the medical measurement device, or connected to it via cables. Changing connecting cables with wireless links improves also quality of life of the recovering patients by releasing them from the bed.

People having chronic conditions need to monitor and report their medical status frequently. Nowadays it does not necessarily mean regular visits to medical service providers' premises. Measurements of many of the typical physiological signs can be done without a presence of medical staff. The measured information can then be delivered to the hospital, etc. using wireless or wired communication channels. The same media can also act as a feedback channel for medical advice.

Modern technology will provide lots of existing solutions, e.g., for wireless data transmission from the patient to medical specialists. Cellular networks, Internet and limited area networks, such as wireless local area (WLAN) or body area networks (WBAN) can be used as core networks to build dedicated medical ICT services. Advanced sensor and measurement technologies combined with ubiquitous and mobile communications will give tools to promote novel applications for wellbeing and healthcare. However, integrating real-time medical solutions in operative use requires very stable and robust communication links that are able to adapt to different data transmission needs. In addition, medical gadgets and data from physiological measurements should be easy to attach to the communication systems and protocols.

At the same time, novel approaches should not cause new harmful disorders to human cells or tissues. For example, safe electromagnetic radiation limits should be carefully recognized before utilizing new radio solutions in close body communication. Such a radio technology which utilizes very low transmission power together with a wide bandwidth is an ultra wideband (UWB) technology. Because the transmitted power spectral density of UWB signal is extremely low, its impact on human cells is negligible. UWB is targeted for short range communication links, but its strength is that it can adapt to various data rate requirements. In addition, extremely wide bandwidth offers very accurate positioning capabilities. [2]

An individual can see all these improvements as a remedy for their healing process. However, for society, the benefits come through improved working processes, which mean better efficiency, and finally, overall cost savings in healthcare sector.

III. SOME PROBLEMS IN THE HEALTHCARE SECTOR

Different countries, or continental regions, have their own peculiarities in their disease portfolio. Despite of the different illnesses, the overall problems in cure processes are the same.

New challenges and changes in healthcare sector will be driven the occupation towards continuous movement. The final target is improved nursing processes with less cost, still remaining high quality of care. For example, general medical actions for long-standing diseases have been shown in Figure 1 (adapted from [3]). As it can be seen, the treatment process can be divided into several sections, depending on the seriousness of disorder. The overall trend is that when moving towards right, the nursing costs will increase, accordingly [3]. Due to the future demographical expectations, the patient per nursing staff ratio will be higher and higher, as well as the cumulative healthcare costs in the future, the direction should be changed towards the left side of the graph. This means that the same number of nursing staff and funds available can be used with higher efficiency if the shooting up illnesses can be identified as early state as possible. The key words are prevention of the diseases and promotion of the health.

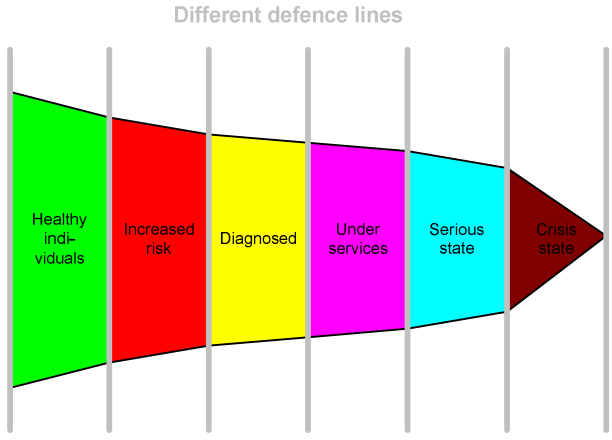

Figure 1. Treatment classifications in long-standing diseases.

One way to improve the efficiency of care process is to merge medical and wireless technologies and advanced service procedures with clinical and medical working cultures. All these fields can improve the care quality but together, the total sum of their impact will be higher than the sum of the individual parts. When replacing cables with wireless links, the current levels of reliability, robustness, secrecy and security need still to be

maintained. Finally, it will have a positive influence on public healthcare costs.

IV. The Innovation Process

Building new innovative service systems and solutions should be based on the actual needs coming from the end-users' requirements. Reverse adaptation of new manners or technologies is typically not successful, independently of the final utilization area. New solutions should reflect the application based demands, so then there will be a natural interest amongst the possible end-user groups. Merging basic and applied studies under one topic is the most efficient way to drive technological development. Due to the conservative approach the medical side has, the renewal process will still take time. The additional delay comes from the tight acceptance procedures the devices and processes dealing with human health have. However, limited piloting phases having as much environmental and user variability as possible during the development process are helping also the regulators in their work by providing evidence based data and real expertise.

Instead of the typical linear innovation process model, we suggest a circular model for medical ICT field (Fig. 2). The circular structure is continuous and more adaptive. For example, it is much easier to describe different functions and operators during the whole process if compared to the linear model. Depending on the new ideas and operations, it is also possible to start the innovation process at different stages of the circular model. This increases also flexibility. On the other hand, the same player can be involved in the different phases of the innovation process, depending on their own expertise and capability. The most important issue still is that the inputs for the processes are coming from the real needs; from end-users, potential customers, medical service providers, hospitals, etc. The circular innovation process can be split into different phases: Needs, Research, Piloting & Assessment; Business; and Services.

Needs

As pointed out earlier, the needs are coming from the field, not being technology oriented. Not only being medical operators, the inputs can be based on the needs of insurance companies, occupational health units, municipals, and also from the consumers themselves. The main point is that there is, at least, one existing party that can utilize novel solutions immediately. This forms the major booster for adopting the results in operational use.

Research

Research phase is, as the name says, the real innovative period of the whole process. Combining several inputs coming from different players in the field will form boundaries to where the actual research and development work will focus on. The novel academic solutions will be verified through the peer reviewed publication processes and the applied part will create solutions for piloting and testing. Typically the research work is carried out by academia, supporting by the polytechnics, and other research institutes. However, joint work between different schools, research institutions and research units at industry will be the optimal way to create new innovations.

Piloting & Assessment

This part of the innovation process focuses on the real experiments carried out in the real end-user environments, or laboratories. The previous phase is typically led by the research institutes but this phase allows more participation also from industry and by the service providers. The output of this phase is experience how novel ideas and solutions fulfill the given demands or how end-users feel about new devices, software, processes, etc. The response can also be used as a feedback to the research phase if more than one iteration is needed during the process. Instant feedback from users' side will help greatly to improve the whole innovation process.

Business

For wider exploitation and commercialization of the novel results, the solutions need to be marketed and sold, nowadays, globally. The final return is calculated by the success of business after the new product is on market. The innovation process can generate completely new companies or strengthen the business of existing companies. In innovation processes, marketing studies are always needed to convince investors and incubators behind the novel ideas. This cannot be omitted neither in medical ICT solutions. Time for market studies is typically before the final product development starts. It can also give important inputs for research phase.

In conjunction with the whole innovation process, the business studies can find out new directions for commercialization or new ideas to produce information for further analysis. In that sense, there is a possibility to create needs for new processes.

Services

Apart from technological innovations and solutions, the novel gadgets or processes in the healthcare sector need assistance from service providers. The final user for measured physiological data is typically a doctor working at hospital or health centre. In this type of model, the service is typically provided by cellular etc. operator who makes it possible to transfer measured information far away. On the other hand, the service provider can be municipality, third-party company or the hospital itself. In an innovation circle, the services provided by these operators can create needs also for the whole innovation process. For an individual person, the services can relate to remote monitoring, health training in prevention, creating a feedback channel for vital data analysis, etc. One example for service provider's task is being a preliminary information desk between the patient and medical professional at hospital. Medical services, which offer advice or guidance for people before they register to hospital, will reduce the hospital's workload if self-care instructions can be delivered beforehand.

The innovation circle with mutual interconnections is summarized in Figure 2. The direction for innovation process is marked with solid lines and possible feedback paths with dashed lines.

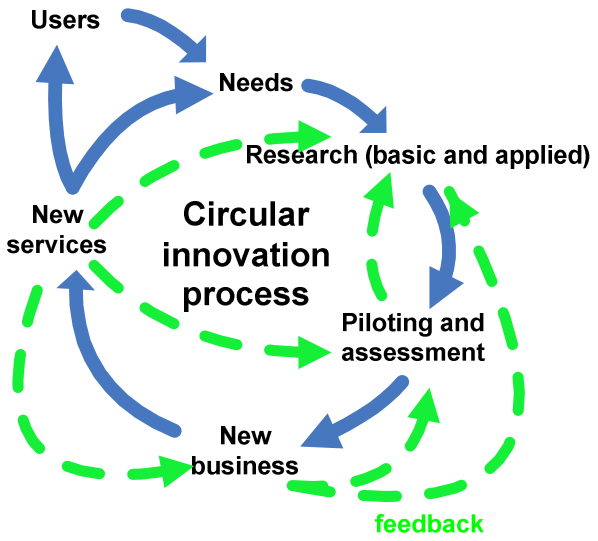

Figure 2. Innovation circle.

V. SOLUTIONS

In medical ICT field, wireless technology can offer lots of benefits and new insights, e.g., in increased patient safety, mobility and quality of care. In addition, the benefits go to hospital administration via higher efficiency, which can be seen as a better patient throughput, and hence, decreased costs.

Within the successful innovation process, the existing knowledge should be maximally utilized. For example, human measurements and diagnostics combined with the evidence based applications will provide fruitful background for further research and development work. Our major idea is to merge wireless communication also to this more medical oriented topic. Using wireless technology, data measurement and delivery can be done regardless of a place and time. The only requirement is availability of a wireless network which allows access for different devices.

Non-invasive and invasive sensing methods which report automatically parameter values can currently be produced. It is possible to manufacture devices which are easy to wear and install, but are still disposable. Seamless and ubiquitous wireless communication technologies can support the security and secrecy levels that are needed in human's personal information transmission. The challenges might still come from the energy harvesting if the medical device's expected lifetime is measured in years but the reporting periods are dense. Acceptable battery change interval is heavily dependent on the application and installation.

If it is possible to minimize the number of hospital or health center visits for a patient, much nursing time can be released for caring those patients who are in a need of more intense care. At the same time, the indirect costs will be decreased, for example, due to the diminished travel needs. From economical viewpoint, this means savings in the medical services but also savings for the patient him/herself.

The current technology has already a level that makes it possible to utilize advanced methods and procedures in medical and welfare applications. To increase the benefits still, more integration between the existing systems, technologies and branches of science are needed. Similar kind of basic solutions can be utilized, for example, in medicine, sports and exercise/training applications. Measuring different kind of physiological parameters in different environments does not change drastically the whole idea of the communication path from the information source to the final destination. Of course, the final application has reflections to same part of the system (data rates, communication regularity, propagation media, etc.) but the structure of the main concept can remain the same. Dual-use, or multi-use widely, merged with scalability and flexibility of the obtainable system, will increase its potential markets and number of end-users, and thus, keeping the gadgets' and services' prices low.

As an example from the Oulu region, the innovation process can include players in University level from several faculties (technology, medicine, natural science, and economics), university of applied science, national research center, public and private hospitals, municipality, city and industry. The final goal of this work is to create a fruitful field of co-operation which outputs new innovations, new business models and new business. The society benefits by lowering healthcare costs and increased quality of provided healthcare services, as well as increased taxes paid by individual employees and companies.

VI. CONCLUSION

Wireless technology will give a great help to introduce new medical gadgets and working procedures. The use of wireless technology allows also remote healthcare, such as telehealthcare and remote surgical operations. There are lots of new possibilities though some of the ideas are already in operative use.

In this paper, we introduced a circular innovation model applied in medical ICT research. Our goal is to encourage multidisciplinary work jointly with different institutes and knowledge backgrounds. The work carried out for helping healthcare and welfare sector should be two directional between the developers and end-users. Based on our expertise, novel solutions which are not originated from the final users do not have as positive future than the ones whose origin is at the real needs. Feedback from the field and end-users need to be directed to research stage of the proposed innovation process. When taking into account the limitations and requirements from different sides of the playground, the novel procedures and gadgets can be most effective integrated into the operational use.

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