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Health care in the information society. A prognosis for the year 2013☆

Reinhold Haux [a,*], Elske Ammenwerth [b], Werner Herzog [c], Petra Knaup [d]

[a] Institute for Health Information Systems, University for Health Informatics and Technology Tyrol, Innrain 98, A-6020 Innsbruck, Austria

[b] Research Group Assessment of Health Information Systems, University for Health Informatics and Technology Tyrol, Innrain 98, A-6020 Innsbruck, Austria

[c] University Hospital for Internal Medicine, University of Heidelberg, Bergheimer Straße 58, D-69115 Heidelberg, Germany

[d] Department of Medical Informatics, University of Heidelberg, Im Neuenheimer Feld 400, D-69120 Heidelberg, Germany

Abstract

Our society is increasingly influenced by modern information and communication technology (ICT). Health care has profited greatly by this development. How could health care provision look in the near future, in 10 years, or more precisely, in the year 2013? What measures must be undertaken by political and self-governing health institutions, and by medical informatics research, to ensure an efficient, medically advanced and yet affordable future health care system? Three factors will greatly influence the further development of information processing in health care within the near future: the development of the population, medical advances, and advances in informatics. These factors have motivated us to set up 30 theses for health care provision in the year 2013. The theses cover areas of health care, such as its people, its information systems, and its ICT tools. Three major goals requiring achievement have been identified: patient-centered recording and use of medical data for cooperative care, process-integrated decision support through current medical knowledge, comprehensive use of patient data for research and health care reporting. In consequence, political institutions should provide a framework for networked, patient-centered health care. They are called on to regulate the storage and exchange of health care data and of appropriate information system architectures. Finally, the health care institutions themselves must emphasize professional information management more strongly. Relevant research topics in medical informatics are: comprehensive electronic patient records, modern health information system architectures, architectures for medical knowledge centers, specific data processing methods ('medical data mining'), and multi-functional, mobile ICT tools.

Keywords: Medical informatics; Health care; Information society

☆ The paper is based on a presentation of the same title, given by the first author on July 6, 2000 at the 'OFFIS-Day 2000' of the Oldenburg Research and Development Institute for Informatics Systems and Tools (http://www.offis.de). In choosing the year 2013, we are making reference to the 100 years, which have passed since Karl Jasper's work 'General Psychopathology' [18] was first published. The physician and philosopher Karl Jaspers, born in Oldenburg, was active at the University of Heidelberg over a long period of time. An extended German version of this paper has been published in [12].

* Corresponding author. Tel.: +43-512-586734-802x800; fax: +43-512-586734-850; http://www.umit.at

E-mail address: reinhold.haux@umit.at (R. Haux).

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1. Introduction

Our society is continuously being influenced by modern information and communication technology (ICT). Health care has already profited extensively from these developments. As an important part of our society, the health care sector represents a considerable economic and financially attractive area for informatics[1] research and ICT industry. Each of us has some sort of relationship to the health care sector, some closer than others. It has become difficult for us to imagine that someone has never been inside a physician's practice or a pharmacy. As hospital patients, many of us have gathered personal experiences with the institutions of our respective health care system.

In this paper we will attempt to answer two questions:

- In regard to the development of ICT, how could health care provision look in the near future, in about 10 years, or more precisely, in the year 2013?
- What measures should be undertaken by political and self-governing health institutions, and by medical informatics research and development groups, to ensure an efficient, advanced, and yet affordable future health care system?

On the brink of the 21st century, numerous institutions and people have concerned themselves with the future development of ICT and health care provision (e.g. [1–3,7,10,11,13,14,19–21,26–32]). For the German hospitals, e.g. Arthur Andersen has prognosticated that the total gross sales of the health product and health service market will more than triple by the year 2015. The major reasons for this being the continuous rapid medical–technical advances, the increase in life expectancy, the 'over-aging' population, the barely changing demand of health consumers, and stable performance standards [4].

[1] The term 'informatics' is used here synonymously to the term 'computer science'.

2. Health care provision and informatics today

We would like to characterize the current state of ICT and health care by some numbers. They describe, as an example, the situation in Germany. Although the numbers reflect various years, they cover mainly the time between 1995 and 1999. Their quality varies. In many cases they are based on (subjective) estimations, in rare exceptions on conscientious surveys and primary data collections. The figures have been rounded to the necessary precision, more exact figures can partially be found in the listed references. Figures on ICT and health care in other countries can be found in [6,15,17].

2.1. Informatics, information and communication technology

A brochure published by the German Federal Ministry of Economics and Technology in 1996 foresees: 'At the brink of the 21st Century, the leading industrial nations, therefore, including the Federal Republic of Germany, stand before a leap in their economic–technological developments, toward an information society. This transition is not a vision, but already fully underway. Today, across the globe, more personal computers are being sold than automobiles. Almost every economic branch is somehow effected by the use of information technology. Terms, such as Internet, data highway, and multimedia can no longer be thought out of our language. In the very near future, the lives of individuals at work, or in everyday situations, will be changed by the information technologies, just as they were by the base technologies before' (translated from [9]). The international information industry (computers, telecommunication, and media—including print—and consumer electronics) held a market share of over 1.5 quadrillion Euro in 1993 [9].

According to the German Federal Ministry of Economics and Technology currently 1.7 million people are employed in the ICT industry in Germany, making up approximately 4.5% of all employed Germans. The gross sales for ICT in 1998, was approximately 100 billion Euro, tendency increasing. The German National Department of Trade and Commerce estimates that the ICT market now surpasses the automobile industry [8]. The sale of personal computers increased in Germany by 19% in 1998, to reach 5.5 million items. For the first time, the number of television sets sold has been reached by this figure. The number of Internet users in Germany has increased to 9.9 million users [8].

2.2. Health care provision

In 1996, the total cost of health care in Germany, was approximately 270 billion Euro, 59% of which covered treatments, while merely 8.4% went for preventive care and other care measures. In comparison, 5 years earlier, in 1991, health care costs totaled approximately 100 billion Euro [24]. An overview published in 1999, by the Organization for Economic Cooperation and Development (OECD), shows that Germany's health care costs consume 10.5% of the country's gross domestic product [5].

Approximately 4 million Germans were employed in the health care sector in 1995. This is an average of 11.2% of all employed Germans [24]. The number of people directly involved in patient care was 1.9 million in 1998 [24]. Adding to a work force of 1.1 million in nursing or other related areas of patient care (in 1998: 785 000 nurses and midwives, see [24], these health care professionals constitute 27% of those employed in the health care sector (1995, see [25]. In 1999, approximately 700 000 Germans were in need of care and made use of services offered through the governmental care insurance policy, requiring 0.9 billion Euro for home care. Of the 291 000 professionally active German physicians in 1999, 126 000 worked in practices and 138 000 in hospitals [25]. The total number of physicians was 363 000). In 1998, the number of pharmacists was 52 000 (1998, see [24]).

In the 2250 German hospitals (1997, see. [24], with their 1.1 million employees (For 1995, see [25]), 15.5 million cases were treated (1997, see [24]). The hospitals' budgets (net overall costs) totaled to approximately 50 billion Euro [24]. Since 1970, the average length of stay in a hospital has nearly dropped by one half [24] to 11.0 days (1997, see [24]. Physician and dental practices numbered 91 000 in 1995. In 1998, an average of 22 000 pharmacies was counted [24].

2.3. Figures relevant to university hospitals

The following figures are presented to show the extent of information processing in university hospitals. As examples, they are oriented toward the figures of the Heidelberg University Medical Center (see, e.g. [23]). Approximately 8000 employees care for approximately 50 000 inpatients and 250 000 outpatients each year. The Heidelberg University Medical Center encompasses over 100 wards, approximately 1700 beds and 70 outpatient units. The yearly gross budget is approximately 500 million Euro.

Each year approximately 250 000 physician letters, 20 000 surgical reports, 30 000 pathology results, 100 000 microbiology results, 250 000 radiology results, and 1 000 000 clinical chemistry resultsare generated. Around

300 000 new medical files are set up each year containing approximately 6 million documents. In terms of conventional archiving, a file volume of around 1500 m is generated each year. Files are generally archived for 30 years. Currently, the data volume for digital storage is estimated at 5 terabytes per year, tendency increasing due to new radio-diagnostic methods. Approximately 1000 archived medical records are accessed each day.

Over 3000 computers are networked, including approximately 40 larger computer systems. This allows integrated, computer-supported information processing in the areas of hospital management, diagnostic ancillary services, on wards and outpatient units. Over 2000 computers serve physicians and nurses at their work places on these wards and outpatient units as health care professional workstations. These systems provide health care professionals with access to most of the mentioned documents as part of an electronic medical patient record, to record data, or to allow the creation of new documents. The systems also support organization and access to medical knowledge via the Internet.

2.4. The importance of informatics for health care

The numbers and examples given above serve to demonstrate the key role of ICT today, without which many hospitals and physician practices (currently the two most important health care institutions, at least in Germany) could not provide adequate patient care. These installations represent an attractive market for the ICT industry. Presently the annual hardware and software requirements of the approximately 40 university medical centers in Germany are estimated to total between 50 and 200 million Euro. The European market for hospital information systems is estimated to be 2.6 billion Euro [17].

It can be observed, however, that in most German practices and hospitals, administrative tasks, such as accounting, represent the largest area of computer application. The support of physicians and other health care professionals, as well as, clinical and epidemiological research, could still be substantially improved. Information processing is primarily directed toward the information needs of the respective institutions, that is of the physician practices or the hospitals. This stands in apparent contradiction to the fact that patients are not solely treated in physician practices or hospitals.

Based already on the current network of shared care, more patient-centered and less institution-centered information processing is desirable, including telemedicine. Improving information, decreasing test redundancy and patient transportation would improve the quality of care.

3. Health care provision and informatics in the near future

3.1. The three decisive factors: development of the population, advances in medicine and in informatics

How could health care look in the near future, in 10 years, or more precisely, in the year 2013, particularly with respect to ICT? We see three factors that will further intensify the advance of ICT and its tools within the technically advanced nations:

- One aspect is the evolution of the population's age distribution. This is often referred to as 'over aging', a term which implies a negative connotation. Due to considerable social and economic developments, and to successes of modern medicine, especially in the area of acute diseases and health care provision, which, historically, can be seen as the best of all times, the average life expectancy has gradually increased during the past decades. Fig. 1 shows Germany's expected age distribution in 40 years. Due to these successes, and the steady increase in life expectancy, chronic diseases and geriatric multi-morbidity necessarily must receive more attention. The complexity of the diseases is increasing as a consequence. This, in turn, requires an increased specialization of health care professionals. It also requires a higher amount of cooperation among them. This, in turn, can be efficiently supported by modern ICT.

- Secondly, the continuing advance of medicine must be considered. New diagnostic and therapeutic methods, many of which are possible only through the use of computers, will increase the quality of health care. Diagnosis and therapy will become more differentiated in the future. It can be expected that our society will make use of these new medical possibilities, even if the cost of health care increases as a result. An increase in diagnostic and therapeutic methods will consequently lead to an increase in information processing. The new methods will deliver an even higher quantity of individual results, which all require coherent, connected interpretation. The already practiced division of work load in patient care will increase in importance in the future and, therefore, require increased communication between the individual groups. Also, the need for patients and their families to inform themselves about the diseases and respective diagnostic, therapeutic and care possibilities will increase, especially the need to seek consultation of physicians in this regard.
- The third factor arises from the advances in informatics. It is undisputed that a considerable advance in information proces-

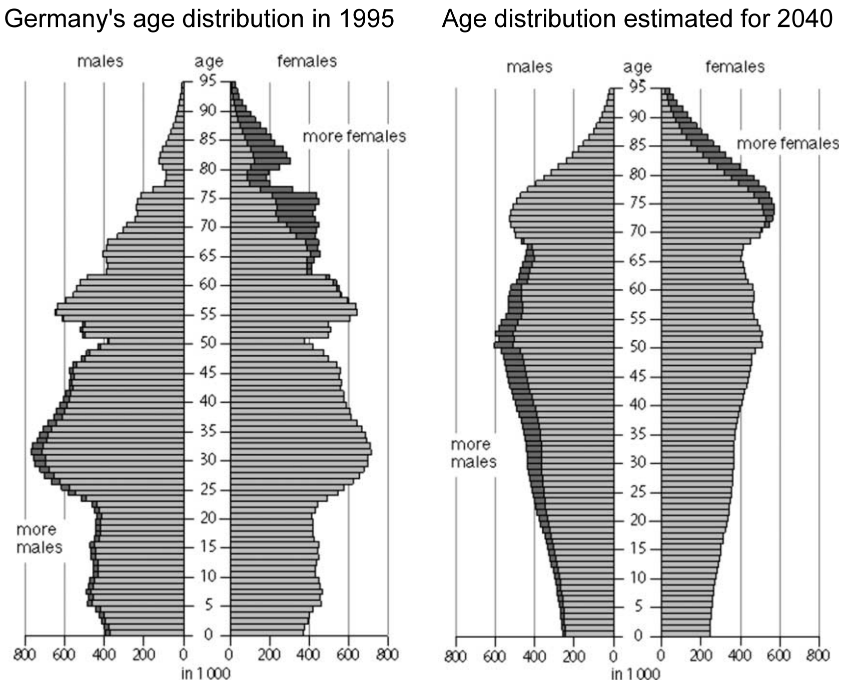

Fig. 1. Germany's age distribution in the year 1995 and 2040 [25].

sing methodology and ICT took place within the second half of the 20th century. For example, the wide-spread access to computer systems, software products, and the world-wide network, the Internet. The numbers presented regarding the development of informatics attest to the progress in access to information and knowledge through ICT. Nonetheless, we are still at the beginning of a development, the ultimate outcome of which eludes us.. These advances will provide us with even more possibilities to improve health care in respect to higher quality and efficiency.

3.2. Theses and prognoses

In the following, we present some (subjective) theses regarding health care provision in the year 2013, taking the ICT tools assumed to be in use at that time into consideration. The *theses* are marked with the symbol 'T'. We have strived to find exemplary prognoses, which may verify, or falsify these theses, however, not until the year 2013. These *prognoses* have been marked with the symbol 'P'. The theses and prognoses apply to Germany. They stand on the assumption that no major political crisis will occur and that the economy and technology will continue to develop positively, without major complication (e.g. breakdown of computer networks or an energy crisis).

A. The health care system

T1: Due to the changes in the structure and usage behavior of the population, the demand for health care services will continue to increase.

P1.1: The share of health care costs will rise above 12% of the gross domestic product.

P1.2: The number of individuals employed in the health care sector will increase to over 13% of all employed in Germany.

T2: The basic structure of the health care sector (physician practices, hospitals, health insurance agencies, etc.) will, in essence, remain unchanged. However, due to rising costs, a higher share will fall on outpatient care services.

P2.1: The number of inpatient beds will decrease by 20%.

P2.2: The average length of stay for inpatient hospital care will decrease below 7 days.

T3: The increase in costs and in patients' quality awareness will strengthen the importance of integrated, cooperative alliances, e.g. between hospitals and physicians' practices. These health care alliances will force the boundaries currently existing between in and out patient care further into the background.

P3.1: Over 60% of all service providers will take part in cooperative alliances.

P3.2: Over 80% of all patients will be treated within such alliances.

T4: Medical advances and increasing costs will fuel the formation of highly specialized care centers. The use of tele-medical methods for exchanging information will increase. However, the spread of such methods will depend on secure, attractive payment for such services.

P4.1: At least 10% of severely ill patients, or those with complicated cases, will make use of tele-medical second opinion.

P4.2: Tele-therapy, in the sense of long-distance operations (tele-surgery), will, however, remain the exception and remain under the 10% mark.

P4.3: Tele-diagnostics and tele-therapy, in the sense of long-distance recommendations to local specialists in low population areas, in special situations (e.g. on see, in space, military assignments in crisis areas, etc.), and in cases of rare diseases, will increase so considerably that they will account for 50% of all health care measures.

T5: Due to the increase in costs, the question of service provider quality will become even more important. Therefore, accreditation guidelines will arise, allowing hospitals and health alliances to certify themselves.

P5.1: Over 40% of the hospitals will be certified.

P5.2: Ninetyfive percent of the service offers will be contained in indices available publicly over the Internet.

T6: Due to increasing costs, different financial models will become necessary.

P6.1: Over 10% of the outpatient costs will be invoiced by using rates for diagnosis related groups.

P6.2: The private participation of patients in their own health care costs will increase. The share of these costs will increase over the 12% mark.

B. People involved in health care

T7: The specialization of health care, with regard to disciplines as well as professions, will continually increase. This will result in a higher division of work tasks and in an increase in communication needs.

P7.1: The number of professional career groups within existing career fields (e.g. specialization of physicians in specific areas) will increase by 20%.

T8: Due to the population developments, and the increased cost pressure, the importance of outpatient and home care will increase considerably.

P8.1: The number of outpatient health care professionals will increase by 30%.

P8.2: The number of patients in need of home care will increase by 40%.

T9: Patients will further emphasize the value of 'their' family physicians as health care advisors. The importance of such professionals will increase.

P9.1: Over 70% of all patients will have a specified family physician.

T10: Patients, especially long-term and chronically ill patients, will establish long-lasting partnerships with their physicians, and will be highly knowledgeable of their specific illness. This will be increasingly accepted by the physicians.

P10.1: Over 40% of those patients suffering severe, or long-term illnesses, will have informed themselves before visiting a physician and will bring information material with them to the consultations.

T11: Patients and their families will be knowledgeable of the information resources available over the Internet and will make use of them. New services will arise.

P11.1: The number of accesses to Internet sites providing medical content will increase by more than 30%.

P11.2: Over 20% of all patients will inform themselves via the Internet about available diagnostic and therapeutic service offers.

P11.3: Over 95% of all households will have access to the Internet.

C. Health information systems

Documentation.

T12: The development, strived by many individuals, to replace the patient record by a life-long health record has not yet been established. Data relevant to patient care are, therefore, still primarily held separately by the various institutions involved in the care process (hospitals, practices, other health care provision institutions, alliances). However, the importance of internationally available data will increase (accessible via the Internet and chip-cards).

P12.1: Over 90% of all data relevant to patient care will be stored on location, at the treating institutions.

P12.2: Over 5% of all patients will have international access to their patient data via the Internet.

P12.3: Medical data will be stored on chip-cards for over 10% of all patients.

P12.4: No legal regulations will exist about where patient data may be stored, either primarily with the patient, or on location at the treating institution.

T13: It will be necessary to establish clear, unique patient identification on a national, EU, and international level. Legal regulations will be initiated, but not yet enacted.

P13.1: A unique, national patient identifier will not yet be available.

P13.2: Over 90% of the hospitals, and over 50% of all alliances, will internally use a unique patient identifier.

T14: The documents of the institutions and alliances will increasingly be available electronically.

P14.1: In over 10% of the hospitals, at least 80% of the documents will be stored electronically and be accessible by the physicians and health care professionals at their workplaces.

P14.2: However, less than 5% of the hospitals will completely give up paper documents.

P14.3: A university clinic will require a storage capacity of over 300 terabytes (= 10 terabytes per year) for storing electronic patient records. This will be financially and practically feasible.

P14.4: In over 5% of the hospitals, more than 50% of the modalities (X-ray, ultrasound equipment, etc.) will be connected to the electronic patient record systems.

P14.5: Storage standards for archiving documents will emerge. It will be assumed that these standards can ensure long-term storage (comparable to paper).

P14.6: However, the question of long-term storage media, comparable to paper, will remain open. It will still be necessary to migrate archived data from one storage medium to another.

T15: Documentation expenditures within the clinical sector will grow due to the increasing complexity of diseases, legal requirements and the necessity for cooperation and communication. At the same time, more efficient ICT tools will become available.

P15.1: The extent of the documents resulting from daily patient care will increase by more than 50%.

P15.2: The required time increase will not rise by more than 20%, especially for institutions using efficient documentation tools.

Communication.

T16: Data (patient care data, fees, etc.) will primarily be exchanged electronically.

P16.1: At least 80% of the data exchanges within a health care institution, or alliance, will take place electronically.

P16.2: Data exchanges between health care institutions, or alliances, will increase by more than 25%.

P16.3: The exchange of documents between institutions, or alliances, will take place electronically in over 60% of the cases.

P16.4: Compulsory standards will exist for electronic data exchange between health care institutions.

T17: Beside personal contacts (conversation, telephone), electronic mail has become a standard form of communication.

P17.1: Over 90% of all written contacts between institutions will be by email.

P17.2: Appointments for patient care, admission, etc. will, however, be made primarily by telephone, 20% will be made electronically.

T18: The importance of cryptographic methods and digital signatures will continue to increase. The electronic signature will have will have become accepted.

P18.1: Over 80% of all official electronic documents will be signed digitally only.

P18.2: More than 90% of the electronic, patient related communication between institutions, or alliances, will be encrypted.

P18.3: Over 90% of the professionals working in the health care sector will use a 'Health Professional Card' to identify themselves and to sign documents.

T19: The importance of email, as a form of physician-patient communication, will increase.

P19.1: More than 70% of the hospitals and over 20% of the practices will allow qualified members of their medical staff to answer patient questions by email.

Medical knowledge and decision support.

T20: Knowledge about diseases will be current, comprehensive and internationally available via electronic media, including their availability to patients and their family members ('consumers'). This knowledge will be available in different qualities. Therefore, internationally accredited certification will be available for their contents (e.g. by specialty associations). Knowledge support will partially be integrated in clinical routines. This, among others, will result due to guidelines, or aggregated diagnostic or therapeutic knowledge, in reference to evidence-based medicine.

P20.1: Over 80% of polled medical knowledge will result from electronic media (over 95% of the polls coming from the Internet). Paper-based reference works will find seldom use.

P20.2: Over 80% of the guidelines used routinely in clinical work, will be available electronically.

P20.3: Less than 10% of the medical Internet sites will be certified. Health care professionals will answer questions pertaining to patient care for more than 50% of the certified sites.

P20.4: In over 10% of the hospitals, over 30% of the guidelines used in clinical routines will be integrated in application systems for the electronic patient record.

T21: Decision support systems, which actively give diagnostic and therapeutic advice, will not yet have established themselves. Passive decision support functions, e.g. allowing reference to the next step in a certain therapy, will have further established themselves.

P21.1: Health care professionals will actively seek assistance of decision support systems in less than 10% of all the diagnoses they make.

P21.2: Over 10% of the complex treatments in hospitals (chemotherapy, radio-therapy, operations, etc.) will be planned with the active assistance of systems offering decision support functions.

Research and reporting.

T22: The type and extent of heath care reports will continually increase. It will be possible to publicly call up and evaluate aggregated data of in and out patient diagnoses (e.g. current prognoses in regard to 'health observation centers': announcement of epidemics and infectious diseases, etc.).

P22.1: In and out patient diagnoses are available via Internet in the form of aggregated data.

P22.2: Less than 5% of the diagnoses will be up-dated on a weekly basis.

T23: Clinical research will be supported by online data, however, only if electronic patient records are available and the data has been stored in a structured manner. It will become evident that comprehensive, systematic planning will be necessary to make use of the data for research.

P23.1: Hospitals storing over 80% of all patient documents electronically (compare P14.1) will base over 50% of their clinical research publications on online data obtained in routine clinical tasks.

Information systems management.

T24: Management of information systems will be perceived as an independent and important division in hospitals. The Chief Information Officer (CIO) will be established and be equally responsible for technical, organizational (business process analysis and optimization), and content related tasks (data analysis for reporting and quality management).

P24.1: More than 60% of all hospitals will have a CIO.

P24.2: The number of informatics specialists active within the health care sector will increase by more than 30%.

P24.3: Over 20% of all hospitals will approve a written strategic information management plan.

T25: The costs of information processing will rise due to the increase in related tasks and specifications.

P25.1: The average share of investments in computer-based ICT tools will rise above 10% in all hospitals.

P25.2: Over 20% of a hospital's operating costs will be caused by information processing.

T26: Increasingly, ICT companies will arise offering technical and organizational support to health provision institutions, e.g. tactical, strategic and operational information management.

P26.1: Over 80% of the ICT projects crucial to the health care institutions' business strategy, will be contracted out to such ICT companies.

D. ICT tools in health care

T27: The use of computer-based ICT tools will increase dramatically in hospitals, practices, and other health care institutions.

P27.1: Over 80% of the hospitals will make computer-based ICT tools available to nearly every clinical workplace and to every health care professional.

P27.2: Over 98% of the privately practicing physicians will make use of computers.

P27.3: At least 20% of the patient rooms will be equipped with a computer in the inpatient health care sector.

T28: Beside telephones and personal computers, mobile communication end devices will be in use for communication and data entry. New mobile ICT tools support communication (speech and text, direct and asynchronous (telephone and email) and organization (calendars and task lists)). The connection of mobile end devices will be achieved asynchronously through 'docking stations' or synchronously via radio waves.

P28.1: The average number of ICT tools in hospitals will surpass the average number of employees.

P28.2: The mobile ICT tools will find use in over 10% of the hospitals, however, wide spread use will be achieved in only 5%.

P28.3: On average, the hospitals will use more mobile than 'stationary' ICT tools.

P28.4: Mobile ICT tools at the clinical work places will posses data transfer rates large enough to transfer nearly all patient data via radio waves, with the exception of videos.

T29: The use of computer-based ICT tools for direct, permanent monitoring of patients' vital signs, as well as the direct, synchronous transfer of these data to health care institutions, will increase. This will result in part through implanted devices (insulin pumps, etc.).

P29.1: Special computers will regularly monitor the health condition of over 5% of the chronically ill patients (vital signs, i.e. pulse, blood pressure, etc.) and transfer the results to the treating health care institution.

P29.2: In over 5% of the chronically ill patients, these special computers will also be used therapeutically, for example by administering a specified dosage of a prescribed medication when the monitored parameters drop or rise above a specified level.

T30: The importance of reference processes will increase.

P30.1: Reference processes exist for core organizational processes, i.e. admission, transfer, cooperative care, within, as well as, among health care provision institutions.

P30.2: The quality of the processes will be decisive in the accreditation of the institutions.

3.3. Example

The following example serves to demonstrate part of our theses. We would like to point out, that we have only concentrated on future aspects of information processing. These theses, however, are based on current knowledge of diagnostics and therapy. The names and institutions mentioned below are fictitious. Portions of the text referring to the presented theses, have been set in italics. The respective theses have been referenced at the end of each paragraph.

The initial situation

Alfred Adam felt the first signs of coronary heart disease (CHD) in the year 2000, at the age of 56. He experienced tightness in his chest when physically exerting himself. The complaints had persisted over a period of 1.5 years, however, as they were not specific, Adam did not seek treatment. During the year 2001, he first began feeling signs of angina pectoris during the night time, leading him to consult his family physician. Dr Eve Bright measured his blood pressure and monitored his cardiac activity using a stress-ECG. In this she noticed a lowering of the ST-segment, possibly indicating impaired circulation of the coronary arteries. This leads the physician to refer Adam to the Plötzberg Medical Center and Medical School (PMC) for outpatient heart catheterization. The examination revealed blockages in three coronary blood vessels, one of which showed an approximately blockage of 95%. During the examination, a stent (a flexible wire structure used to unblock a blood vessel) was implanted into the main blocked vessel. Afterwards, the Adam received medication at PMC (beta-blocker, anti-anginas medication, anti-coagulant). Regular follow-up consultations with Dr Bright revealed that Mr. Adam suffered from diabetes mellitus and a light form of depression. Careful, comprehensive questioning enabled Dr Bright to uncover that Adam had been suffering from light depressive moods throughout the past 15 years and recommended he consult a physician trained in psychotherapy.

In the year 2013.

Mr. Adam's blood pressure remained high even though it was medicated. He was required to take further medication at the risk of an overdose.

Among other things, during the year 2010, Adam had been prescribed a newly developed tiny computer system 'Vital-Online', in form of a fingering, which he constantly carries with him. In addition, a micro-ECG chip 'Cardio-Watch' was implanted in close vicinity of his heart. (T29)

Vital-Online measures Adam's vital signs every 30 min, while Cardio-Watch permanently monitors his ECG. Both sensors transfer their data via radio waves to the information and communication assistant (InCoA) of his family physician. (T9, T29)

Before the data is transferred to Adam's electronic patient record, which is located at the physician's office, a 'Heart20XX' system scans it for possible signs of a heart attack, based on special, knowledge-based therapy guidelines. These guidelines also take past data into account. Heart20XX posses an interface to all common electronic patient record systems and can be preemptively switched, in form of a filter, by the physician. (T21, T27)

The license fees for Heart20XX are reimbursed to Dr Eve Bright by the health insurance company, because the software has been certified and has proven itself in numerous trials. The trials show that early discovery of ECG aberrations can improve the success of the treatment. Many health provision alliances allow membership to physicians and hospitals only if they use knowledge bases as permanent filters. On March 14, 2013, at 4:50 a.m., Alfred Adam suffered a heart attack at the age of 69. The attack caused acute pain in the chest, neck and left arm and was accompanied by nausea and dizziness. Adam can not get up and suffered respiratory complaints. He did not want to call a doctor, so his wife opened a window to allow for fresh air. (T3, T5, T27)

Because she was unsure, Adam consulted two certified Internet databases on heart diseases. For the given symptoms, both urgently recommend her to call a doctor. (T10, T11)

At 5:45 a.m., via Internet and the InCoA of the practice, Adam demanded to speak with Dr Bright. The computer had already alarmed Dr Bright due to the monitored vital signs, so Adam was put straight through to the physician. (T17, T20)

At 5:50 a.m., while Eve Bright sent an ambulance to the Adams' apartment via her mobile T27 computer 'CellComProfessiona14', she also personally examined the vital signs and ECG T28 reports generated by the InCoA via CellCom. To notify the ambulance, she identified herself using her digital physician identification. At 6:10 a.m., the ambulance arrived at her patient's home. (T18)

In the mean time, using her CellCom system, Dr Bright communicated Adam's admission to the Plötzberg Medical Center. She granted PMC permission to access Adam's electronic patient record and the CHD data located their, not, however, the data referring to the depression. Due to contracts of the alliance, the data was transferred in encrypted form. (T3, T12, T18)

An ECG was conducted in the ambulance, resulting in the diagnosis of an anterior myocardial infarction. The results and the diagnosis were then directly transferred from the ambulance to the electronic patient record via radio waves by the ambulance's InCoA, as well as to the InCoA of her practice and of PMC. (T16)

Adam arrived at PMC at 6:30 a.m. Additional administrative admission of Adam was not necessary, as the data had already been made available. (T14)

PMC and Dr Bright used different formats for patient identification. Due to security reasons, a manual 'record linkage' of Adam's past data had to take place. To minimize the possibilities of an incorrect assignment, a documentation specialist conducted this procedure. The lab exam, immediately initiated upon the patient's arrival, showed an increased level of creatininkinase at 800 U/l (indicating a heart attack). The patient immediately received a catheter examination in which an attempt was made to unblock the vessel supplying the anterior portion of the heart. A stent was again implanted and anti-coagulation medication administered over a 12 h period. The patient remained in intensive care at PMC for 1.5 days and then on an inpatient ward for 3 further days. (T12, T13)

The medication recommended in Adam's case was stored in his electronic patient T21 record at PMC. A knowledge base module of the PMC's InCoA, responsible for monitoring side effects and interactions of medication, marked the recommended medication as safe. It automatically generated a warning that Medication X could not be recommended in cases of depression, and Medication Y in cases of obstructive lung disease. (T14)

The patient was asked to participate in a clinical trial of Medication Z. Alfred Adam agreed and the relevant data was extracted from his electronic patient record and copied to the documentation system. (T14, T23)

Upon discharge from the hospital, a letter was generated by PMC's information system and send to Dr Bright directly via email. Also, the physician was permitted to access the data accrued during Adam's stay at PMC. Following his stay in the hospital, Adam took part in an outpatient infarction rehabilitation program, three times a week, at a center approximately 2 km from his home. (T16, T17)

He communicated with Dr Bright via email several times a week. (T19)

Due to the depressions, Dr Bright discontinued the use of Medication X and researched for an alternative product in the Internet. A week after his release, the patient complained to Dr Bright about

respiratory problems, fever and yellow discharge. Dr Bright examined the patient, took X-rays of the chest and diagnosed a lung infection. Her patient recovered at home by taking antibiotics. (T20)
Dr Bright treated Adams according to the guideline for ‘hospital acquired pneumonia’. To simplify the documentation, the treatment measures are automatically taken from the guideline and entered into the patient record. Adam’s rehabilitation efforts were briefly paused. (T20)
The practitioner informed the PMC about the lung infection via email, as the disease was possibly acquired there. Within PMC, the ward physician on duty informed PMC’s information system via his duty CellCom, thereby updating the quality statistics. (T17, T28)
The regional infection warning system was automatically notified to keep the daily infection statistic stored there up to date. (T22)
Upon recovery and after finishing the rehab program, Adam regularly attended a cardiac fitness group, trained by a specialist for cardiac fitness. (T7)
The patient continued to use the Vital-Online and Cardio-Watch sensor systems. (T29)
In the mean time, Dr Bright replaced her mobile computer CellComProfessional4 with the follow-up model ‘CComP5+’. This computer allows her to be notified directly, should her patients’ vital signs derail. This investment was also reimbursed by the health insurance company. Half a year later, Alfred Adam suffered another angina pectoris attack while on vacation in Mallorca. He immediately consulted a physician of the island, a German speaking Internist named Dr Gonzales. (T28)
Adam carries the most relevant data regarding his CHD with him on a chip card. This data is stored in such a way, that it can be read in several languages. Adam allowed Dr Gonzales to view the data. As Dr Gonzales did not fully understand the German data, he viewed them in Spanish. (T12)
The practice of Dr Gonzales is certified in regard to business processes. He conducted a stress-echogram and contacted the responsible physician at PMC for a second opinion. Both physicians saw no need for further intervention. (T4, T5)
During the course of his CHD, Alfred Adam gradually developed a heart anxiety problem. He has trouble keeping these symptoms apart from true angina pectoris symptoms, occasionally leading him to call Dr Bright at night. She, simultaneously to Adam’s calls, monitors the current results via her CellCom. The CellCom communicates with the InCoA of her practice, over which she can access her patient’s vital signs. (T9, T28, T29)
Adam regularly searches in the Internet for data pertaining to his heart anxiety problem and keeps himself informed about diagnostic and therapeutic measures to treat CHD and its possible signs. During his consultations with Dr Bright, he often reported of new treatment measures available in the USA. He considers going there to undergo treatment. Dr Bright has had good experiences with conversation therapy in such cases, and recommends her patient

to a colleague already known to Adam. (T11, T20)

3.4. Remarks

The areas covered by our theses and prognoses have been selected subjectively and do not claim completeness. For example, we have left out society's attitudes toward ICT tools and the changes brought on by their use. It remains necessary to discuss to which extent ICT is seen as an obvious technology in the year 2013, one that is desirable in support mankind, and not a menace to it. In this regard, critical movements may arise directed against technical dependency and against the possibility of not over-seeable complexity arising from personal experience and media reports.

Presumably, whether a person communicates with another person or with a machine will not have such an importance then as today.

Furthermore, it can be expected that assistant tasks will increasingly be replaced by ICT tools (the tools become the assistants). It can be assumed that a physician, for example, will order a care measure or make an appointment personally, during his rounds, rather than asking a member of the nursing staff to do so. Reports of results will be generated immediately and automatically (possibly via voice input), instead of dictating and passing them on to clerical staff members. It may be that, initially, this will be felt as a loss in prestige. However, in time, it will be recognized as a release from dependencies. The basic tasks of a physician will not be affected by this.

Furthermore, it can be assumed, that architecture of buildings, in particular for interior design, and architecture of information systems will move closer together and will be planned cooperatively.

In viewing these, in our opinion, far-reaching changes facing health care provision, the necessity of training the specialists and users of ICT becomes apparent (see, e.g. [22]).

4. Goals and measures

4.1. The three main goals: patient-centered recording and use of medical data for cooperative care, process-integrated decision support through current medical knowledge, comprehensive use of patient data for research and health care reporting

Based on the prognoses we have established, we would now like to formulate goals which, in our opinion, ought to be reached by medical informatics for health care within the near future. In this work, we will not go into other important medical informatics topics, such as those regarding the improvement of diagnostic and therapeutic measures, which are, by far, not limited to genome research (see [11] and, as example, [16]).

The first goal we see is the patient-centered recording and use of medical data for cooperative care. Patient-centered refers to health care across health care institutions, and to the fact that information processing is not concentrated around just one hospital. It also means that all health care professionals, especially physicians and nurses, have access to relevant patient data, according to their respective authorizations. The possibility of using and analyzing the data includes the patient himself. Data is usually summarized in document form, e.g. result reports, physician letters, results, images, and series of images. In order to reach our first goal, various obvious prerequisites must be met. Use, independent of location, times and of the person, can only be realized by the electronic patient record. Uniform terminology and standardized documentation is necessary for the people and institutions involved in patient care. Especially in a unifying Europe, language independent recording will be important. Such an extensive electronic patient record requires more cost effective and easier to handle devices for storing and using data, for organizational support and communication between and within the involved health care institutions. The information processing and communication enabling personal computers and telephones currently available, as impressive as they may be, can not be seen as ideal. Patient-centered storage and use of data should serve to avoid repetitive examinations, and to massively increase the availability and usability (or, may be, better: analyzability) of the data, reduce efforts involved in accessing the data, and improve the communication options. All of this aimed, of course, despite the increasing cost of health care, at providing at least the same quality of care, using approximately the same amount of people and money.

The second goal we have identified is process-integrated decision support for all health care professionals by way of current, valid and comprehensive knowledge. This knowledge, required by diagnostics, therapy and care, must be current and of high quality. Beside the classical knowledge of diseases (their causes, appearances, effects, diagnoses, therapies, prognoses, and prevention), organizational knowledge of service offers will be of growing importance. This knowledge should fit the knowledge level and needs of its users. It should also be well integrated into the clinical work routine and be accessible from the clinical work place. Beside physicians, nursing professionals and other specialty groups, the availability of knowledge is equally important for patients and their family members ('consumers'). In this case, it is also apparent that the use of such knowledge best be computer-based. Two levels are principally conceivable. One level could be a weaker form of access to medical knowledge, independent of the users' specific knowledge level of the subject and their needs. Another level could be a more extended form of integrated knowledge processing, which takes specific patient data, or the users' specific knowledge levels and needs, into account.

The third goal we have identified comprises the comprehensive use of patient data for clinical and epidemiological research and for health care reporting. In consideration of data protection, scientists have the opportunity to easily analyze current medical data available from almost every step of the health care process. Today, almost every physician has access to high quality, affordable published material via MEDLINE. Likewise, clinical and general epidemiologists should have access to local, regional, national and international patient-related, yet anonymous, data of diseases, treatment successes, and complications. Beside terminologically uniform documentation, systematic planning of data processing plays an important role in clinical and epidemiological research, which should not be underestimated. Only if a well planned electronic patient record can be made available, will the type of use necessary for introducing, e.g. computer tomography or magnet resonance tomography, be achieved.

While striving to achieve the three mentioned goals, the overriding goal must remain, that the health care system of an information society must be developed for, and not against mankind. This includes safe, controllable technology. Data protection and security are of extreme importance for sensitive medical data. Making own decisions, seeing technology as a helper, and the relationship between a patient and the health care professionals involved in her or his care, can be seen as primary requirements for their success. In addition, it is always important to assess, whether the costs of ICT stand in a reasonable relationship to its benefit.

4.2. Necessary measures by political organizations, self-governing health institutions, and medical informatics research and development groups

Which necessary measures must be undertaken by political and self-governing health institutions, and by medical informatics research and development groups to ensure an efficient, medically advanced and yet affordable future health care system?

Political institutions should provide the foundation for a networked, patient-centered health care system. The development of practical organizational and technological frameworks, a system of reimbursement, which strengthens cooperation, targeted support of research, and investment incentives for the ICT industry are of special importance. It should be mentioned that within recent years many important aspects have been noticed and addressed by various institutions, state governments, and by the European Union. In this regard, most frequently under the heading 'telemedicine', the development of frameworks has begun. Beside a practical electronic signature, the legal acceptance of digitally stored documents and the regulation of a framework for electronic patient data exchange over networks, have been two major advances. However, much remains to be done: The development of an uniform European digital patient identification system and the regulation of patient data storage for cooperative use in patient care and clinical research must be addressed. Medical knowledge centers (offering current, valid and comprehensive medical knowledge to specialists and patients), health care reporting, and clinical and epidemiological research across health institutions (based on the collected patient data) must be supported.

The self-governing institutions are called on to put forth regulations for transfer and storage of health care data, as well as, regulations for suitable information system architectures. A start has already been made, but must be continued if our health care system is to remain efficient while its frameworks are changing. Frameworks specifying how patient data can be accessed and used by practices, hospitals and other health institutions, as well as by patients at home, are required. Hereby, it should not matter, e.g. whether the data has been generated by a privately practicing physician or by a hospital. If these frameworks have been successfully specified, the ICT industry will be better equipped to invest in a financially attractive market and in the development of modern products. The structure of reimbursements must be changed in such a way that, for instance, physicians who avoid repeated examinations or unnecessary patient transportation receive financial incentives. If done correctly, it could even lead to a cost reduction.

The health care institutions, especially hospitals, must emphasize professional information management more strongly in their organizations. University medical centers must set up knowledge centers for certain diseases and offer international services, for example, in the areas of patient counseling and second opinions. As before, the necessary reimbursement structure must be established.

The research environment can expect various topics to remain of utter importance:

- Structuring and testing comprehensive electronic patient records, which support the casuistic use of patient data for direct patient care, and which allow patient group analyses and use of data for research and reporting.

- Conception and testing of suitable information system architectures that support co-operative, patient-centered and cross-institutional care.
- Conception and testing of system architectures for 'knowledge centers' offering specialized medical knowledge world-wide via the Internet.
- Conception and testing of methods for medical data analysis ('medical data mining') based on modern information system architectures and electronic patient records and aimed at clinical and epidemiological research, as well as health reporting.
- Integration and testing of comprehensive, practical, useful and mobile ICT tools for patient care.

Successful research in these areas, and the successful implementation of the frameworks mentioned, will set patient care and medical research on new, future-oriented foundation and will help strengthen financial developments. The term 'information society' would then, most probably, apply to health care.

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