Redesigning healthcare: The 2.4 billion euro question?

Connecting smart technology to improve outcome of patients

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Abstract Although it has been possible to transfer electrocardiograms via a phone line for more than 100 years, use of internet-based patient monitoring and communication systems in daily care is uncommon. Despite the introduction of numerous health-monitoring devices, and despite most patients having internet access, the implementation of individualised healthcare services is still limited. On the other hand, hospitals have invested heavily in massive information systems offering limited value for money and connectivity. However, the consumer market for personal healthcare devices is developing rapidly and with the current healthcare-related investments by tech companies it can be expected that the way healthcare is provided will change dramatically. Although a variety of initiatives under the banner of ‘e-Health’ are deployed, most are characterised by either industry-driven developments without proven clinical effectiveness or individual initiatives lacking the embedding within the traditional organisations. However, the introduction of numerous smart devices and internet-based technologies facilitates the fundamental redesign of healthcare based on the principle of achieving the best possible care for the individual patient at the lowest possible cost.

Conclusion The way healthcare is delivered will change, but to what degree healthcare professionals together with patients will be able to redesign healthcare in a structured manner is still a question.

Keywords e-Health · Electronic health records · Healthcare costs

Introduction

Approximately 110 years ago, Willem Einthoven was the first person to use telemedicine by sending clinically obtained ECGs by telephone to his laboratory located outside the hospital, because his ECG machine was not allowed on the wards [1]. It took another 80 years, however, to invent and distribute the personal computer (PC, introduced 1981). This event marked the beginning of the widespread use of PCs [2]. In 1991, the ‘World Wide Web’ or internet was introduced, thereby allowing computers to exchange digital information, and within 5 years companies in different sectors started offering services via internet [3]. By 2013, 97% of the Dutch population had internet access and online banking and online shopping were used by 83 and 82%, respectively, of this group [4]. Furthermore, in the Netherlands 90–98% of all inhabitants can use fourth-generation mobile networks (allowing mobile access to fast internet) and 85–95% of the land area is covered by the two dominant mobile providers.

Computers have also revolutionised healthcare. Laboratory results, diagnostic images and patient records became available online in most hospitals and it became possible to exchange data between healthcare providers. General practitioners (GP) also use PCs to record patient data, and currently 98% of Dutch GPs are storing information in electronic health records.

The current hospital information systems (HIS), however, still have major limitations. Systems are expensive, complex, and connectivity of most systems is limited. Furthermore, commercially developed/used applications such as video-consultation systems, telediagnosis and teletherapy systems are only used by a small number of healthcare providers. The possibilities to extract data out of these applications into the HIS are still limited [5]. With respect to
In this paper we will try to outline the future of healthcare and to discuss a patient’s journey.

For this to become reality, training of healthcare providers should change, patients have to be involved in redesigning the system and reimbursement systems should be able to finance healthcare chains rather than individual actors. Furthermore, instead of focussing on too-big-to-fail HIS all efforts should be focused on developing dedi-
e-Health

As stated above, e-Health is not very well defined [7, 8]. The Dutch Board of Public Health (Raad voor Volksgezondheid, RVZ) defines e-Health as ‘the use of new information and communication technologies, especially internet technology, to support and improve health and healthcare’ [9]. The World Health Organisation (WHO) on the other hand defines e-Health as ‘the transfer of health resources and healthcare by electronic means’ [10]. This difference is significant, as the RVZ’s definition indicates a supportive approach to e-Health, whereas the WHO’s definition indicates a more substituting approach. E-health, irrespective of the definition used, remains a broad term. To clarify this we propose to subdivide e-Health into separate entities as shown in Table 1.

**Impact of e-Health implementation**

There are numerous examples of e-Health-related studies in the literature. The problem in comparing them is that, although two studies can both be e-Health-related, the methods used can differ substantially. Diseases subject to numerous e-Health research projects are arterial hypertension, diabetes and heart failure (HF). Several studies have demonstrated positive effects of telemedicine on outcome of both arterial hypertension and diabetes patients [11].

The results of telemedicine on the outcome of HF patients are, however, conflicting. Telemonitoring studies using implantable cardioverter-defibrillators (ICDs) demonstrated that remote monitoring of the ICD in HF patients enhances life expectancy and reduces the number of related clinical events [12]. The value of phone support systems on the other hand remains debatable. One systematic review found that phone support systems reduced hospitalisation and all-cause mortality in HF patients [13]. However, a large clinical trial comprising 826 HF patients randomised to a phone-based telemonitoring system, and 827 HF patients randomised to regular care found no differences in all-cause mortality or hospital readmission rates. Moreover, there were no differences in the number of patients readmitted for HF, the number of days in hospital or number of hospitalisations [14].

**Where to go from here?**

With the introduction of all kinds of smart devices and internet-based technologies, it is possible to redesign healthcare. What do we need? First of all, define the needs of the individual patients, so involve them in the design process. Secondly, introduce dedicated applications to provide both patients and healthcare providers with the optimal information needed at the correct time and place. These applications should be connected to the patient data stored safely in cloud-based systems. Data stored in these systems should be available for registration purposes, to get reimbursement and to benchmark healthcare systems.

The leading principle as stated by Porter in 2012 should be: ‘achieving high value for patients must become the overarching goal of healthcare delivery, with value defined as the health outcomes achieved per dollar spent’ [15]. The present generic HIS lack all the criteria defined above. Firstly, initial costs (30–60 million euro per hospital) and costs to keep systems up-to-date are extreme. Secondly, due to the top-down generic design principles it is
**Table 1** Different entities of e-Health

| Entity                  | Description                                                                 |
|-------------------------|-----------------------------------------------------------------------------|
| E-public health         | Encompasses all actions taken using information technology to improve and protect health on a society level |
| E-support               | Encompasses logistical actions needed in healthcare, such as patient access to their own patient files/medical records |
| E-care                  | Supports the interview, physical examination, treatment and follow-up using electronic devices |
| Telemonitoring          | The process in which patient parameters are measured remotely. Various devices measuring for instance blood pressure, electrical activity of myocardial cells, oxygen saturation and patients weight are used in clinical practice [17] |
| Teletreatment           | The process in which patients are treated from a remote distance [17]       |
| Teleconsultation        | The process in which doctors are consulted from a remote location, using video or email technology, by either colleagues or patients [17] |
| Telediagnosis           | The determination of the nature of a disease at a site remote from the patients on the basis of telehealth methods of transmitted data [17] |

**Table 2** Reimbursement

| What is reimbursed?                                                                 | Problems with reimbursement?                                                                 |
|------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|
| Screen-to-screen contacts                                                          | Teleconsultations from a general practitioner to a medical specialist are not reimbursed (currently, only teledermatology is reimbursed) |
| Telemonitoring (after negotiation with healthcare insurance companies)              | Reimbursement is not in proportion to the time an e-Health intervention takes |
| Telemonitoring and screen-to-screen contacts (STSC) in which the patient is contacted using video-telephony, can be reimbursed | Reimbursed only if a STSC is both a substitute for a face-to-face outpatient clinic visit and if this STSC is a follow-up visit of a previous face-to-face outpatient clinic visit |

**Table 3** Mindset of involved stakeholders

| Stakeholder            | Mindset                                                                 |
|------------------------|-------------------------------------------------------------------------|
| Medical staff          | 1. Are overwhelmed by information from electronic health records and devices  
                          | 2. Experience a lack of reimbursement for e-Health  
                          | 3. Have concerns about the quality of the data generated by e-Health and m-Health devices |
| IT specialists         | Are not well enough instructed on what health information doctors need at what time |
| Patients               | 1. Do not always understand what is written down in their electronic health record, because of what is often referred to as ‘doctors language’  
                          | 2. Sometimes lack proper experience with information technology, especially smartphone technology |
| Managers               | Have concerns about the logistics of control of the data                |
| Nursing staff          | Are afraid that they will be overwhelmed with data                       |

Difficult to fulfil all the wishes from the different healthcare providers for all scenarios encountered and most systems are full of compromises. Furthermore, due to the obsession of all the parties involved (insurance companies, financing departments, inspectorates, ministry of health, scientific societies) to register, store and report an ever-growing dataset that can be accessed always and everywhere, the design of currently used HIS may lead to the so-called information completeness paradox. In managerial cultures, completeness of data is thought to be a kind of holy grail helping to be in control. However the overload of accumulated data with no particular hierarchy in a patient file may, especially in critical situations, prevent the healthcare professional from taking the correct decisions [16]. Furthermore the current systems are, despite some initiatives, not really informative for the patients themselves.

Therefore, in order to regain control it should be realised that information systems in themselves add no value, but that the value comes from how information is handled. So how to start? By adopting a leading design principle based on the SET (Safe, Effective and Transparent) principles. How to translate this into practice? It is envisioned that a patient has his own patient records stored in the cloud. This virtual record starts at birth and continues to build up during life. In this virtual record all healthcare-related events are stored. Every healthcare provider involved works with a dedicated application which can be obtained from a Medical Application Store (MAS). The MAS contains specific certified applications in which information is gath-
ered and stored in the patient virtual healthcare record. Each stakeholder in the medical field has his own application: cardiology, pulmonology, pharmacy, general practitioners, nursing staff, etc. If a patient is admitted to the department of a relevant stakeholder, that stakeholder activates his or her application and stores the information. In the example (Fig. 2), the paediatrician switches on the paediatrics application at age 5. At the very same time, the information is automatically translated into lay terms, making it understandable for patients. This information is visible in a patient-specific analogue of the application, obtained by the patient from the Patients Application Store (PAS). Each application in the MAS, has an equivalent in the PAS. The PAS contains patient specific information, which encompasses a lay description of the data gathered in the MAS (and made available in the patient cloud), as well as both general and specific information, such as instruction videos and the anatomy and physiology of a relevant organ. The MAS furthermore contains a separate folder in which the physician can write notes which will not be copied to the PAS. The content of MAS and PAS is defined by relevant stakeholders, including medical specialists, patient organisations and educational specialists. Applications should be based on open source software. Furthermore, connectivity and data exchange should be easy. As suggested in Fig. 2, content, design, and certification are brought together in
the so-called 3-P application design studio (Patient, Professionals and Public). Following this software structure, the information will be to-the-point to the physician, understandable to the patient and transparent to the public. Structured storage of information enables easier data extraction for quality assessment purposes [18].

**e-Health implementation**

Despite the potential advantages of redesigning healthcare as discussed in the previous section several problems may hamper the rapid and widespread implementation of e-Health. First, instead of reimbursing individual healthcare providers, thereby creating artificial borders between the different sectors, it will be necessary to reimburse healthcare systems. Currently, however, several financial constraints for e-Health implementation are repeatedly reported and summarised in Table 2. Second, it is important to recognise possible hesitations by the involved stakeholders as summarised in Table 3. Third, it is important that data safety is ensured and monitored by an independent inspectorate. Furthermore it is vital that patients are able to refuse the exchange of their data between healthcare providers and that access rights are well described.

It will be important to address these barriers in redesigning healthcare and to stimulate all involved. In other words, change the mindset!

**Conclusions**

The question is not if the way we provide healthcare will change, but to what extent healthcare professionals together with patients will be able to fundamentally redesign healthcare in a structured manner. This process should start with defining the needs of patients based on the principle of best achievable care at the lowest possible costs.

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**Ethical standards** The accompanying manuscript does not include studies on humans or animals.

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