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Home informatics in healthcare: Assessment guidelines to keep up quality of care and avoid adverse effects

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Abstract. Due to an ageing population and improved treatment possibilities, a shortage in hospital beds is a fact in many countries. Home healthcare schemes using information technology (IT) are under development as a response to this and with the intention to produce a more cost-effective care. So far it has been shown that home healthcare is beneficial to certain patient groups. The trend is a widening of the criteria for admission to home healthcare, which means treatment in the home of more severe conditions that otherwise would require in-hospital care. Home informatics has the potential to become a means of providing good care at home. In this process, it is important to consider what new risks will be encountered when placing electronic equipment in the home care environment. Continuous assessment and guidance is important in order to achieve a safe and effective care. Based on a review of current knowledge this paper presents an inventory of risks and adverse events specific to this area. It was found that risks and adverse events could stem from technology in itself, from human-technology interaction conditions or from the environment in which the technology is placed. As a result from the risk inventory, this paper proposes guidelines for the planning and assessment of IT-based hospital-at-home schemes . These assessment guidelines are specifically aimed at performance improvement and thus to be considered a complement to the more general guidelines on telehomecare adopted by the American Telemedicine Association (ATA) in October 2002.

Keywords: Assessment, home informatics, hospital-at-home, telehomecare

1. Introduction

The term home informatics is frequently used denoting the application of emerging information technology products for use by private households and includes hardware, software, networks, and services [20]. Home health services based on home informatics are under development in many countries

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and have been tested as an alternative to in-patient care to solve the problem with shortage of acute and long-term hospital beds. Today more severe health problems can be treated and a growing number of elderly people have caused an increased need for professional healthcare. Hospital-at-home is practised increasingly as a response to this and to restrictions in public healthcare reimbursements, which is a fact in many countries. A Cochrane review [25], to assess the effects of hospital-at-home compared with in-patient hospital care, found no significant difference in outcomes and no evidence of cost savings in either a social or care provider perspective. Home healthcare is nevertheless an attractive alternative for many patients and their families, which justifies the trend as long as quality of care is kept on a high level and patient and carer satisfaction equals or surpasses in-hospital care.

Hospital-at-home has been referred to as "a service that provides active treatment by healthcare professionals, in the patient's home, of a condition that otherwise would require acute hospital in-patient care, always for a limited period" [25]. In this we have widened the definition to also include chronic diseases and handicaps, which could be treated at home using new information technologies. Telemedicine has been defined as "the use of electronic communication and information technologies to provide or support clinical care at a distance" [28], from which telehomecare can be derived meaning "telemedicine systems designed for the home care setting" [26]. Both hospital-at-home and telehomecare belong to the home healthcare area and overlap in many aspects.

New technologies have enabled treatment in the home setting of conditions that earlier required hospital care. Intravenous drug administration and blood transfusions can now be performed in the home setting [25] and another example of high technology home care is monitoring of high-risk pregnancies [3]. Home informatics can be used both as a means of communication with the patient and for diagnostic and surveillance purposes. Information and communication systems suitable for advanced home healthcare applications are currently under development.

A development program initiated at Linköping University, Sweden, is building a hospital-at-home system for advanced home healthcare [19]. The work is conducted in close cooperation with medical device industry, telecom industry, and the local care provider, which is a hospital-based home care organisation. An interdisciplinary project group is formed, where medical sensor technology and data security issues have high priority. Connecting the patient to a central care provider requires a secure permanent and/or mobile network solution [13,18], which implies that data security has to be considered in every hospital-at-home scheme. A pilot application for patients with chronic obstructive pulmonary disease and congestive heart failure is currently on the way and the aim of the project is to construct an information system, which will enable continuous monitoring of physiological data from body sensors in the home.

Implementation of informatics-based hospital-at-home schemes will probably increase in the near future and will be introduced for more severe conditions. Continuous assessment and guidance in this process is of uttermost importance in achieving a safe and effective care. Healthcare providers and national planning institutes will demand to know the effects of the reorganisation. Assessments of cost-effectiveness and quality of care have been sparse and are not altogether unanimous. The studies done so far are often small and there is a lack of standards as well as a "common language" in the area of telehomecare.

"Hospital-at-home informatics" will also bring new risk considerations to the arena, such as secure data transmission and safe handling of the technology. The fundamentals of secure transmission of information have been described in connection with remote vital signs monitoring in healthcare [11].

2. Objectives

The objectives of this study are to identify risks and adverse events associated with home informatics in hospital-at-home and telehomecare applications and to propose guidelines for early assessment of home informatics-based healthcare schemes. Administration of hospital-at-home can be community based or hospital based. The organisation of telehomecare differs from place to place and we have tried to formulate guidelines, which apply to most countries' telehomecare organisations. Assessment guidelines must also apply to all phases of development, as individual devices and practices in a hospital-at-home scheme can be found at all innovation levels.

New risks and adverse events are bound to be encountered when changing from traditional in-hospital care to informatics-based hospital-at-home. Data security constitutes a major part in telehomecare, but as this has been thoroughly discussed elsewhere [11,13], the emphasis in this paper will be on factors more directly influencing patients and healthcare staff. The aim is to make an inventory of risks, their causes and consequences, and to formulate recommendations to avoid them. This will reduce the risk of long-term adverse effects when the use of telehomecare increases.

The guidelines are intended to support planning, performance, and assessment of telehomecare. Assessment issues will continue to gain ground in the hospital-at-home planning process. In order to support implementation in healthcare it is necessary to produce evidence of effectiveness and cost-effectiveness of the healthcare alternative. Investors as well as private and public healthcare providers must be convinced that the technology is beneficial. An early assessments program will be useful and will favour the development process.

The following questions, which initiated this study, were formulated and have been treated in this paper: What adverse events have been encountered or anticipated in home healthcare and in informatics-based care in particular? What has been done so far to assess effectiveness and quality of care in informatics-based hospital-at-home schemes? What can be learned from assessments of general home healthcare applications?

3. Method

Data collection and analysis were made using the PANTH (Preparatory Assessment of New Technologies in Healthcare) protocol,[1] which is under development at the Centre for Medical Technology Assessment (CMT), Linköping University. The method is a synthesis of information from literature, interviews, discussions and communications based on current knowledge worldwide. An iterative design has been inspired by qualitative methods of research. Data are grouped together in the process of gaining familiarity with the material using alternating data collections and evaluations.

Documents were searched for in four databases: The Cochrane library, Medline, CINAHL, and Science Direct. The following criteria were used for inclusion in the study:

1. Documents dealing with home healthcare or healthcare applications of home informatics, computer technology, or telecommunication.
2. Documents dealing with safety and risk, adverse events, or any aspect of assessment.

[1] Additional information about PANTH will be provided on request by K. Roback (kerro@ihs.liu.se).

Of these criteria, the first had to be met and documents fulfilling both criteria were favoured.

Notes extracted from the documents have been indexed and analysed using a qualitative data analysis package, NUD*IST [22]. Data collection and analysis were conducted as an iterative process. In cases of contradictory conclusions, more data have been collected until sufficient verification of either position.

In the process of making an inventory of risks and adverse events, information on different measures for avoiding adverse events has been collected. This information as well as the assessment notes have been analysed and a synthesis with basic innovation and assessment knowledge has been performed. This synthesis forms the basis for the proposed guidelines for early assessment of informatics-based hospital-at-home projects.

4. Results

Six main categories were discovered (Table 1). These were gradually split into more distinct areas relevant to our research questions. A total of 24 documents [2–12,15–19,21,24–27,29–31], from nine different countries, were included in the study, the most of which are scientific papers. Other documents used are e.g. debate articles and project reports. The documents were scanned for passages containing information belonging to one or more of the main categories. The data were arranged into subcategories, some of which form the subheadings of the following sections about risk and adverse events and assessment guidelines for hospital-at-home.

4.1. Risks and adverse events specific to hospital-at-home informatics

The inventory of risks and adverse events yielded three categories: Technology factors, human-technology interaction factors, and environmental factors. The classification differs somewhat from risk categories in [29], in which human factors are specified and no interaction factors are considered. This modification has been done because absolute human factors are equally present in ordinary home healthcare and regarding informatics related human factors they are almost exclusively of interaction character. Some of the factors can be sorted under more than one category (Table 2), since the same consequences may have different causes. There should perhaps also be an additional category of Organisational factors. One risk factor belongs exclusively to this category, namely discharge from hospital "to save costs" of patients with heavy service needs, who are not suitable for telehomecare [26].

4.1.1. Technology factors

Disconnection is perceived as a severe incident in telehomecare. The cause may be failure of telecommunication links [26], but is also a human-technology interaction problem (see next section). Missed alarms are a risk, perhaps caused by disconnection. The consequences are lost confidence, anxiety, suffering, or even death [29]. A large number of false alarms, though, may also lead to lost confidence and anxiety. This is why calibrating the sensitivity of an alarm system is a delicate balancing act. Reducing false alarms, e.g. from an accelerometer, will inevitably result in more missed alarms [27].

Interference with the equipment by other electronic devices, mechanical defects, poor design, and poor quality are other factors, which make patients fail to connect to their remote care providers.

Hacking and eavesdropping risks [18] are always present when sending personal information from patients at home to a central care provider. The privacy and integrity loss caused by this is not visible to the patients, but may lead primarily to system failure (e.g. exhaustion of disk or memory space and interference) and malpractice and secondarily to loss of patient trust.

Table 1
Coding categories and the number of documents coded under each category

Main category	Number of documents [references]		Scientific papers	Other documents	Country of origin
1. Descriptions of hospital-at-home systems and what telehomecare can do	19	[2,3,5–11,15,17–19, 21,24–26,29,31]	16	3	Australia, France, Greece, Netherlands, S. Korea, Sweden, UK, USA
2. Positive experiences and results	18	[2,3,5–10,12,15–17, 25–27,29–31]	16	2	Australia, Netherlands, S. Korea, UK, USA
3. Negative experiences and results	15	[5–7,10–12,15,16, 19,25–27,29–31]	13	2	Australia, Greece, S. Korea, Sweden, UK, USA
4. Risks and security aspects of hospital-at-home applications	13	[3,6,10,11,15–19, 26,27,29,31]	11	2	Australia, Greece, Netherlands, Sweden, UK, USA
5. Telehomecare assessment issues	18	[2–11,15–17,25–27, 29,30]	17	1	Greece, Netherlands, S. Korea, Spain, UK, USA
6. Recommendations for a good telehomecare system	16	[5–7,9–11,15–18, 24–27,29,31]	14	2	Australia, France, Greece, S. Korea, Sweden, UK, USA
Total:	24		20	4	9

Table 2
A selection of risks and hazards sorted under respective risk category

Technology factors	Human-Technology Interaction factors	Environmental factors
disconnection	disconnection	loose cabling
interference	complicated interfaces	poorly integrated equipment
equipment failure	confusion	equipment taking too much space
eavesdropping	missed alarms	falling
missed alarms	false alarms	impact injuries
false alarms	patient uneasy with equipment	work injuries
	lost confidence	

4.1.2. Human-technology interaction factors

Causes of disconnections can be physical, e.g. stumbling over loose cables, but also erroneous actions in handling the technology. Misuse of the equipment may include playing games on the homecare computer [6], which is a potential risk for memory space insufficiency. One study of telehomecare costs reported that on average almost 25% of the video visits were unsuccessful [7], which partly seemed to be an effect of insufficient training of the nurses. Poor design of user interfaces [31] is an important factor that may cause a number of secondary risks. Faulty appliances [29] may be a consequence of this, as well as of poorly designed instructions. Where manual data entries are required, the risk of incorrect or missing data increases [18]. This is serious if leading to malpractice and subsequent suffering or illness [17]. A high degree of malfunction and error may also cause frustration and dissatisfaction among care providing staff [6].

4.1.3. Environmental factors

A major environmental factor is how well the equipment can be integrated in the home [10]. Patients' homes have to be converted to small care units and are thus also a work environment. Poorly integrated technology may cause both patients and visiting staff to feel distressed and uneasy. Insufficient space is often a problem [6], which is a risk factor to both people and equipment.

A loss of privacy due to surveillance equipment is inevitable. In the patient's view, this can be handled by switching off or disconnecting the equipment [10]. Concerning staff, all their actions could be

traced [18] in the surveillance and monitoring data, which is filed at the healthcare centre. The auditing advantages in this must be weighed against the privacy loss it causes.

4.2. Guidelines for assessment of informatics-based hospital-at-home projects

The guidelines are a synthesis of information found in the investigated documents and general innovation and assessment knowledge. They are presented as recommendations for assessment of informatics-based hospital-at-home and apply to already implemented hospital-at-home schemes as well as to the planning and development process of such schemes. General clinical guidelines for telehomecare have been developed by the American Telemedicine Association (ATA) [1] and were adopted on October 17, 2002. The ATA guidelines contain a general section on performance improvement requiring that "organizations providing patient care must have plans to measure quality of and satisfaction with care". This work contributes with specific guidelines that refine the section of the ATA guidelines on performance improvement.

Assessment aspects must be considered at an early stage, since the design of a study and the context, in which it is performed, is essential for the quality of the assessment. It is also essential to keep up quality of care for patients in these schemes. That is why we have chosen to include aspects on training, education, support, and feedback in the guidelines.

The overall chronological order of the guidelines applies to building a hospital-at-home system. Guidelines specific to assessment of already implemented systems have not been explicitly expressed, but are integrated in this arrangement.

4.2.1. Planning a hospital-at-home system and an assessment study

The planning process: It is preferable to include all staff categories in the planning process [27]. Engage also potential hospital-at-home patients and their families, since lay opinions often prove to be useful. Opinions from people living in the area of the intended study setting should be most valuable.

Goals and objectives: Set realistic goals for the project and make sure they are clearly stated. At predetermined checkpoints assessment data can be used to determine if goals and objectives have been met. It is also important to determine what else the assessment is meant to reveal.

Setting: Investigate if the intended setting is feasible regarding visiting nurses' working conditions and patients' possibilities to receive healthcare comparable to in-hospital care. The technology for data transmission must be available everywhere in the project area. If not so, technology or setting must be reconsidered. It is not desirable to exclude homes because of insufficient transmission possibilities.

Costs: The costs must be analysed to determine budget requirements and the feasibility of implementing the system in the intended setting. When summing up at checkpoints a treatment cost estimate may be presented at an early stage.

Safety and risk: Moving hospital services into the home creates new safety and risk issues. Human-technology interaction factors as well as the changed domestic environment must be considered. The influence that human error has on safety must be evaluated. List all possible erroneous actions that can occur in connection with each device, both in the expected operations and in tasks that are not directly associated to the actual device [29]. Evaluate the consequences of each error and implement measures to reduce the effects, to prevent error, and to reduce causes of error.

Technology considerations: It is convenient to have complete and fixed systems when making healthcare assessments. However, when dealing with evolving technologies, flexibility and development have its advantages. It is important to have a dynamic system that can benefit from the latest achievements in sensor and computer technology. Some basic conditions for updates of devices and software will have

to be determined, though, dependent on economic frames, technology sponsors, education and training possibilities etc. Unnecessary change, e.g. between comparable models or products, is preferably avoided as altered routines may cause frustration among patients and staff.

Ethical aspects: In a situation where places of care in a scheme are too few to meet the demand, there must be a priority setting whether to assign patients according to "first come, first served" or "most possible benefit" principles. These priorities will decide formulation of inclusion criteria in an assessment study and which patients to assign to home healthcare. It is also important to take into account the whole family and residential situation in each case, in order not to put a burden on relatives which they are not capable or willing to bear.

4.2.2. Before installing the system in patients' homes

Patients: Initially patients must be assessed to determine whether the technology is appropriate and acceptable. Cognitive or other impairments may be present that precludes admission. In some cases, though, family members or a personal assistant can bridge over these difficulties. Cases of refusal must be respected, but perhaps a short trial period could be offered, as it has been shown that initial anxiety with using the equipment can be overcome [6] and telehomecare technology can be handled by patients with no computer background [9].

Home environment: Hazards to both patients and visiting nurses can arise, and must be evaluated, before introducing a number of electronic devices and cabling in the home. The equipment must be neatly placed and leave enough space to provide an acceptable work environment for visiting staff. But, above all, it must be beyond doubt that it is safe for a particular patient to remain at home at all.

4.2.3. Training and education

Nurses will have to learn how to install, calibrate, and operate equipment, which is often totally new to them. In the fully implemented system this education can be reduced to staffing changes and technology updates.

Patient education is necessary when telecommunication and monitoring equipment is introduced in the home. Even though adopting a simple design, it is important to provide training and opportunities to gain confidence with the equipment before remote care begins. Training must also be provided to accommodate changes in the system and software. Patient understanding and attitude towards the technology need to be reassessed by the staff during home visits.

4.2.4. Data collection aspects

The evaluation of a project requires collecting relevant data. Decide checkpoints at which to retrieve data. Patients' quality of life, satisfaction with care, and compliance with treatment are important outcome measures. A quality of life questionnaire could be used to obtain data directly from patients to evaluate changes in health status and satisfaction with the offered care alternative. Health status data are also available via vital signs monitoring. Notes on adverse events and incidents should be continuously collected for assessment of safety and risk.

For budget reasons and for the cost analysis, it is important to keep track of resources used. If aiming at estimating patient and family resources used in the care, this should be made partly by qualitative methods, since perceived use of resources may be as good a measurement of the burden as counting the productivity loss, travel costs etc. Patient (and family) use of other health resources may also be considered as well as occasions of rehospitalisation.

4.2.5. Quality of care and patients' attitudes towards hospital-at-home

It is necessary to collect and analyse outcomes data to determine which patients can be treated effectively using the telehomecare system. These outcome measures may be widely different depending on which patient groups will be assigned and the different telehomecare technologies they require. To pick out the patient groups that will benefit most from the technology should be the number one priority in early assessment of hospital-at-home. QOL (quality of life) and ADL (activities of daily living) measurements and telephone interviews could be used as a complement to achieve this.

A major question in assignment of patients in an assessment study is whether to have a control group or not. In order to make a regular cost-minimisation analysis a control design must be applied, preferably with patients randomly assigned to either the intervention group or to a control group. The purpose of random assignment is to minimise selection bias. But independent of randomisation or not, there will be a number of patients (about 50% of the initial study population) that had preferred to belong to the other group. Some of these will refrain from participation [25] when they are informed of their allocated place. This will mean that groups, which are equivalent regarding gender, age, severity of illness, co-morbidity, etc., will still be different regarding patients' attitudes. Furthermore, it has been shown that when including only patients who accepted their assigned care alternative (and excluding those immediately transferred to hospital), an episode in hospital-at-home was substantially cheaper than in-hospital care [16].

Another fact that speaks for selection of the most appropriate and positive candidates is that the number of hospital-at-home beds will initially be too small to provide sufficient statistical power. In that situation the most ethical approach is to choose patients who are expected to be happy with the solution.

For auditing quality of care it is possible to integrate monitoring of quantity and type of care provided [29]. This is not altogether sufficient, but in combination with patients' opinions it may prove useful. The method has the advantage of not influencing normal work, but to the cost of some privacy loss in the work environment.

4.2.6. Assessing safety and risk

Important outcome measures in all three risk categories include number and severity of incidents and adverse events. It may also be useful to assess risky behaviours and perceived risk factors by questioning patients and staff.

Technology: It is necessary to assess the safety for each particular device as well as for the whole system. Failure reports must be analysed. Privacy and confidentiality of personally identifiable medical information must be protected and cases of unauthorised access must instantly lead to measures and a safer system. Electronic patient records, video- and telephone-recordings should be securely stored and in accordance with legislation.

Human-technology interaction: The way people interact with the technology must be evaluated and risky behaviours prohibited by proper training. The influence of human error can be evaluated by analysing notes from erroneous actions and by comparing it to the list of possible errors made in the planning process. The next step is integration of the findings in the continuous risk analysis. All findings should be integrated in the system and the ultimate goal must be absolutely foolproof human-technology interfaces.

Environment: The impact of the technology on patients is very much dependent on how well it is assimilated in the home environment [10]. In telehomecare the home is also a place of work. To achieve a safe work environment, the opinions of visiting staff will be useful.

4.2.7. Cost analysis

In the current phase of development, it is not possible to design a good cost-effectiveness study. Many projects will use several generations of prototypes and technology updates [7], and thus will face the "moving target" problem. It will also be necessary to distinguish between development costs and medical intervention costs, which may cause further hardships. A basic requirement, though, is that the quality of care in the home is at least as good as in hospital, which many studies are pointing at. In that case the cost-minimisation design may be adopted, which implies that only inputs are taken into consideration and the consequences of the interventions are supposed to be the same. But a useful rule is: If you can not make a high quality cost-analysis, do not try it at all. An ordinary bookkeeping will show if the homecare alternative is bearing reasonable costs.

Direct costs: These are costs borne by the community, the healthcare system, or patients and their families. Telecommunication may be a major cost in telehomecare, but expected improvements in both infrastructure and devices will probably lower the costs. Be aware of this and use it as an argument for the choice of discount rate.

It may be necessary to book costs of unsuccessful actions separately, as these in some cases are to be ranged under development costs. This is applicable to e.g. disconnection of video visits, a problem that will eventually be of minor importance. There are often also additional labour costs in the development phase due to education and training needs.

Indirect costs: This category includes productivity losses caused by a problem or diseases. Concerning hospital-at-home it may include the lost productivity of family members who are unable to work because of their care-giving contributions. Other items, which are more difficult to price but could be included in indirect costs, are reduced pain, grief, and suffering, increased quality of life and possibly the loss or gain of leisure time.

Avoided costs: There may be costs avoided by a health care intervention, which would otherwise be caused by the illness. Some studies are pointing at avoided costs due to a lower rate of rehospitalisation and shorter episodes of care in the homecare groups [8,15,16,30].

Discounting: Discounting allows the calculation of present values of inputs and benefits, which accrue in the future. There is no discount rate standard and the matter has been intensely discussed [14], but often 5% is taken as a test value. Another type of discounting is how the costs of equipment should be distributed over the years. In this case the choice of discount rate depends on how many years the individual device will be in service. Often, though, a device will be prematurely exchanged by a more effective and/or cheaper update, which must also be considered.

Sensitivity analysis: It is wise to test how sensitive the cost analysis is to changes in the input variables. Try different conceivable values and picture at least a worst case and a best-case scenario.

Analysis perspective: A decision about perspective must be made. Presumably, the study is initiated to convince a private or public healthcare provider that hospital-at-home is an economic alternative. This will determine if the focus should be on costs at health agency level or community level.

4.2.8. Continuous support and feedback of results

To pave the way for positive attitudes towards hospital-at-home solutions, it is necessary to provide highly available and useful technical support. This will strengthen confidence in the system among patients, relatives, and staff. Though patients and relatives should not be bothered with technical details, it is preferable to leave simple instructions and information in the patient's home and with the visiting nurse.

Continuous feedback of health status data and system assessment data could lead to automatic identification of problems. Thus, interventions can be set in before a major crisis is a fact. The care planning

process could be refined and when a patient does not benefit from hospital-at-home care, providers can address the problem at an early stage and switch to traditional care [26]. Field staff must also be available for home visits whenever the patient's health status requires professional face-to-face care.

System safety must have high priority. Incidents and adverse events must be continuously evaluated and the results integrated in the development process.

5. Discussion

Development of medical technologies can be divided into four phases: pre-clinical development, early clinical development, trials to support marketing, and post-marketing trials. Hospital-at-home, considering the whole system, is about to enter the "trials to support marketing" phase, while individual devices can be found at all levels in the development process. This implies a dynamic system, which give rise to serious problems in the assessment design. Therefore, we suggest a combination of quantitative and qualitative methods in order to capture all aspects of the intervention. We also suggest a continuous feedback of assessment results. The resulting system improvements seem to be beneficial to patients, but will unfortunately complicate the analysis of costs. A solution is to separate development costs from medical intervention costs. This separation must be carefully specified and motivated.

Exchange of knowledge between projects would be useful. Many telehomecare projects are following the same tracks and, despite vastly different healthcare politics and reimbursement systems in the world, collaboration ought to be possible. The next step in an international collaboration is to establish a universal vocabulary and standards to facilitate the extension of findings to other settings and systems.

The telehomecare alternative is often presented as a solution to the shortage in hospital beds and to increasing healthcare costs. Currently, however, there is no evidence of cost savings. A positive effect of treating patients in their homes, though, could be a reduction of nosocomial infections. However, for the time being there is no consensus about what should be called home-care acquired infections, and nosocomial infections are not absent in the home setting. Visiting staff could transmit disease and patients could be infected by antibiotic resistant microbes, which have entered the home through other channels. Appropriate infection control programmes for the home care setting must be developed, since it is common that home-care nurses deploy unnecessary infection control practices to reduce risk [23].

6. Conclusion

The previous section has shown that a number of adverse events are associated with the introduction of electronic equipment to the patient home. Such adverse events are, for instance, accidental disconnection of equipment, mechanical defects, interference with other devices, poor design of user interfaces and unsatisfying integration in the patient home. From the inventory of adverse events, assessment guidelines have been deduced that will make it possible to avoid such adverse events. These guidelines are presented in the chronological order when designing a telehomecare system or study. It becomes clear that frequent feedback to the system designers and their prompt reaction to problems, e.g. through a support team, during all stages of a hospital-at-home design and implementation is necessary to ensure patient and care giver satisfaction.

There has been an overall positive attitude in the reviewed documents, perhaps due to publication bias. We have tried to balance this somewhat in the future trends of telehomecare presented below.

6.1. Future trends in telehomecare

Diffusion of some certain general healthcare and information technologies will be beneficial to implementation of hospital-at-home schemes, such as the electronic patient record, interoperable software and hardware, and affordable telecommunications infrastructure in currently underserved rural areas. These are technologies, which will most likely become widespread in a near future.

Hospital-at-home has a potential to provide care at lower cost in the future, mainly as a response to organisational and technology development. Components in the systems are still being manufactured at decreasing costs and the organisation of telehomecare will most probably become more efficient when more widely implemented. When a smooth hospital-at-home organisation has evolved, education and training costs can be reduced to introduction of new staff and technology updates.

Hospital-at-home has a potential to provide high quality care for certain patient categories and to people who feel comfortable with the technology. The importance of human encounters for quality of life and recovery must not be forgotten, though, and televisits are preferably combined with a suitable number of face-to-face patient encounters. Our work has the intention to be a first step in the direction of well-designed assessment studies for telehomecare applications. Prospective assessments will enable establishment of general rules for system design and patient allocation to produce a hospital-at-home care, which is both cost-effective and will increase patients' quality of life.

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