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DESIGNING MEDICAL INFORMATION SYSTEMS THAT WORK

A User-Centered Approach to Improving the Working Conditions and Quality of Work of Health Care Professionals

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Contents

Abstract

Health care professionals work under difficult circumstances. Heavy workloads, long work hours and difficult decisions are established parts of the medical profession. To ensure the well-being of health care professionals and the safety of their patients, it is important to ensure that health care professionals are not further hindered in their work by difficult working conditions, such as having to deal with confusing information or unnecessarily time-consuming administrative tasks. Information technology has the potential to improve working conditions by simplifying processes and improving information access. However, existing information technology in the hospital workplace widely suffers from poor usability and low acceptance by the health care professionals. This paper examines the approach of applying user-centered design to improve existing health information technology and create new systems to assist health care professionals. Additionally, this paper discusses how user-centered design can improve the working conditions of health care professionals and the safety of their patients.

Introduction

Health care professionals are expected to work under very difficult conditions. Long hours, heavy workloads, and exceedingly complex tasks are established parts of physicians' and nurses' occupations (Steinbrook, 2002). For instance, the maximum amount of hours of work allowed for physicians in training is higher than that for commercial pilots, truck drivers, or nuclear power plant operatives (Steinbrook, 2002). Since the consequences of mistakes in medical professions can directly lead to the injury or death of their patients, it is vital to ensure that the conditions and environment surrounding the health care professionals are optimal to support their work (Institute of Medicine, 2000). Unfortunately, problems in the organizational structure of the health care professionals' working environment additionally complicate their work (Speroff et al., 2010). These include difficulties in accessing important information, suboptimal communication between different parties, and administrative work, such as filling out patient forms, which claim large portions of health care professional's time and energy (Mills, Neily, & Dunn, 2008; Speroff et al., 2010). Collectively these complications can lead to working conditions being very stressful, which can impair both the well-being of the health care professionals themselves and the quality of care they are able to provide for their patients (Baggs et al., 1999; Gawande, Zinner, Studdert, & Brennan, 2003; Gershon, et al., 2007; Karasek & Theorell, 1990; Rogers et al., 2004; Siegrist, 1996; Von dem Knesebeck, Klein, Frie, Blum, & Siegrist, 2010).

Many aspects of the working conditions in hospitals such as information access or repetitive administrative tasks can easily be improved by implementing information technology (Mechanic, 2003). Information technology is defined as technology, which communicates, processes, and stores information (Oxford English Dictionary, 2009). Indeed, health care professionals are increasingly working with health information technology (HIT), such as electronic medical records or decision support systems (Backhaus & Friesdorf, 2006). However, these systems are quite often lacking in usability (Obradovich & Woods, 1996;

Wears & Cook, 2006). The usability of a system is measured by how easy its functions are to understand, learn, and use (Norman, 2002). HIT's deficiency in usability is mainly caused by its not being intuitive enough and not fitting into the workflow of the health care professionals (Aarts, Doorewaard & Berg, 2004; Campbell, Sittig, Ash, Guappone, & Dykstra, 2006; Kindsmüller, Haar, Schulz, & Herczeg, 2009). As a result, systems that were designed to assist and ultimately improve the quality of work end up adding to the workload and increasing the number of mistakes made (Bates et al., 1999; Lederer et al., 1992; Pressman, 1992; Tang et al., 1994; Tierney, McDonald, Martin, & Rogers, 1987).

A main reason why these systems are so difficult to use for health care professionals is that the designers of the system are not familiar enough with the users of the system (the health care professionals) and the conditions in which they work (Koppel et al., 2005; Wears & Berg, 2005; Woods, 1998). The resulting system therefore reflects what the designer believes the user needs and not the user's actual needs. It is therefore necessary to involve the user in the design process to guarantee that the system designed will ultimately be readily usable (Norman, 2002).

The design approach which involves the user from the beginning stages of the design process is called user-centered design (UCD). The goal of UCD is to find out what the user wants, what his limitations are, and how, when, and where he will use the system (Norman, 2002). This information is gathered either from the user directly through interviews or indirectly by observing him in his natural working environment (Johnson, Johnson, & Zhang, 2005).

The aim of this paper is to look at different factors that influence the working conditions of health care professionals, the impact they have on the quality of health care professionals' well-being and the safety of their patients, and especially, how to improve these working conditions by implementing user-centered designed information systems. Different case studies of specific user-centered designed HIT are presented and the potential and the limitations of current research on UCD for HIT are discussed.

Working Conditions of Health Care Professionals

Working conditions of physicians and nurses, in this paper referred to as health care professionals (HP), are often strenuous. Working hours are often very long; with resident physicians, i.e. physicians at the beginning of their medical career, regularly working 24-hour shifts (Steinbrook, 2002). Workloads are heavy and the nature of the work is very challenging (Gurses & Xiao, 2006; Effeken, Kim, & Shaw, 1997; Mechanic, 2003). When confronted with a patient in critical condition, HP have to make life or death decisions in a matter of seconds (Kindsmüller et al., 2009). In addition to these high job demands, working conditions are further complicated by different problems in the organizational structure of the hospital (Linzer et al., 2009). In the following section, some central problems of the organizational structure are discussed.

Information accessibility, which is vital for HP to make informed decisions, is often difficult, because information systems in hospitals are frequently not structured optimally (Johnson et al., 2005). This means that the HP need to search through large amounts of irrelevant data before finding the information that they need (Backhaus & Friesdorf, 2006; Kindsmüller et al., 2009). For example in operating rooms (OR) and intensive care units, the working area is often crowded with a large number of devices, which all compete for the attention of the HP (Backhaus & Friesdorf, 2006; Kindsmüller et al., 2009). Errors can occur because of attention overload, primarily because the relevant information is lost in the large amount of irrelevant information that is also presented (Coiera, Tombs, & Clutton-Brock, 1996). Figure 1 gives an idea of the difficulty of keeping an overview of the patient’s state.

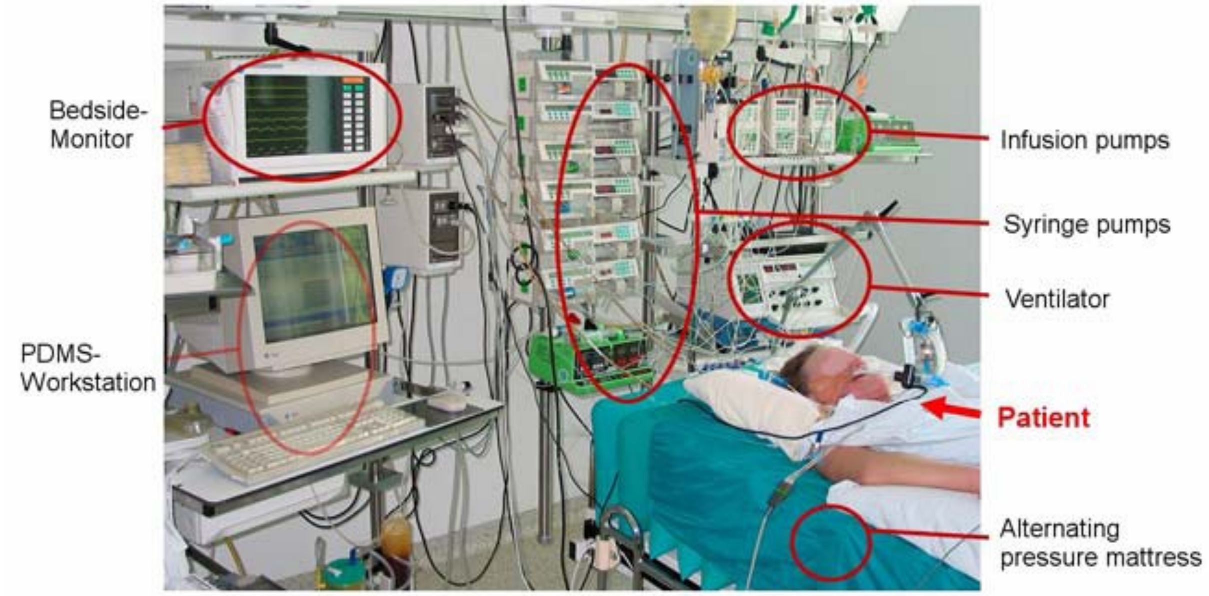

Figure 1. This is an example of the technical equipment in a modern intensive care unit. Instead of assisting health care professionals, the amount of health information technology makes finding the right information more difficult (Kindsmüller et al., 2009).

Since relevant information is not always made readily accessible, communication is very important to ensure that everyone has all the necessary information. A situation in which this is especially important is in the OR. In the OR, however, often only the surgeon has all the information. Everyone else, especially nurses and anesthesiologists, are informed on a need-to-know basis (Wauben et al., 2011). Everyone being well-informed about the patient's case is however very important for patient safety, since in an emergency situation everyone will need to act quickly and have all the relevant information to ensure the best outcome for the patient (Gawande et al., 2003; Lingard et al., 2004; Wauben et al., 2011; Yule & Flin, 2006). Therefore, good communication is vital to patient safety (Leonard, Graham, & Bonacum, 2004; Mishra et al., 2008; Yule & Flin, 2006).

In addition to decreasing the quality of work, failures in organizational factors, such as steep hierarchies that leave little decisional control to the individual, can also lead to an increase in stress and a decrease in work satisfaction for the HP (Kowalski et al., 2010; Sagie & Krausz, 2003). Prolonged exposure to stress and work dissatisfaction can lead to adverse effects on the physical and psychological well-being of HP (Sonneck & Wagner, 1996). For example, Virtanen et al. (2009) found that long work hours, poor communication and high work stress were associated with a higher risk of infection among HP. Stress-factors, such as chronic time pressure, feeling out of control, or not being included in the decision-making process can also gravely decrease the psychological well-being of the HP (Mills et al., 2008; Wauben et al., 2011). The suicide risk and the risk of developing psychological disorders is significantly higher for HP than for the general population (Bright & Krahn, 2011; Sonneck & Wagner, 1996); for both, stress is often named as a likely cause (Reimer, Trinkaus, & Jurkat, 2005; Su, Weng, Tsang & Wu, 2009). Furthermore, burnout, also caused by chronic stress, is very common in both doctors and nurses (Aiken et al., 2001; Demerouti, Bakker, Nachreiner, & Schaufeli, 2000; Soler et al., 2008; Kowalski et al., 2010; Wu, Zhu, Li, Wang, & Wang, 2008). First signs of burnout, such as emotional exhaustion, are highly prevalent in working nurses (Teng, Shyu, Chiou, Fan, & Lam, 2010). Burnout and its forerunners have direct effects on the quality of work of the HP affected, on the number of mistakes made, and on patient safety (Halbesleben, Wakefield, Wakefield, & Cooper, 2008; Spence Laschinger & Leiter, 2006; Teng et al., 2010).

The poor working conditions of HP therefore affect patient safety both directly and indirectly: (a) Directly, by the quality of working conditions promptly influencing patient safety – for example, the amount of information about a patient that a physician can easily access will influence the accuracy of his decision as to the patient’s further care requirements (Duffin, 2003; Haynes et al., 2009; Seki & Yamazi, 2006); (b) Indirectly, in that a decrease in the well-being of the HP, caused by the poor working conditions, will lead to a decrease in the quality of work that the HP are able to provide, which then again decreases patient safety (Figure 2). It is therefore both in the interest of the HP and of the patients to ensure that the working conditions of the HP are as optimal as possible.

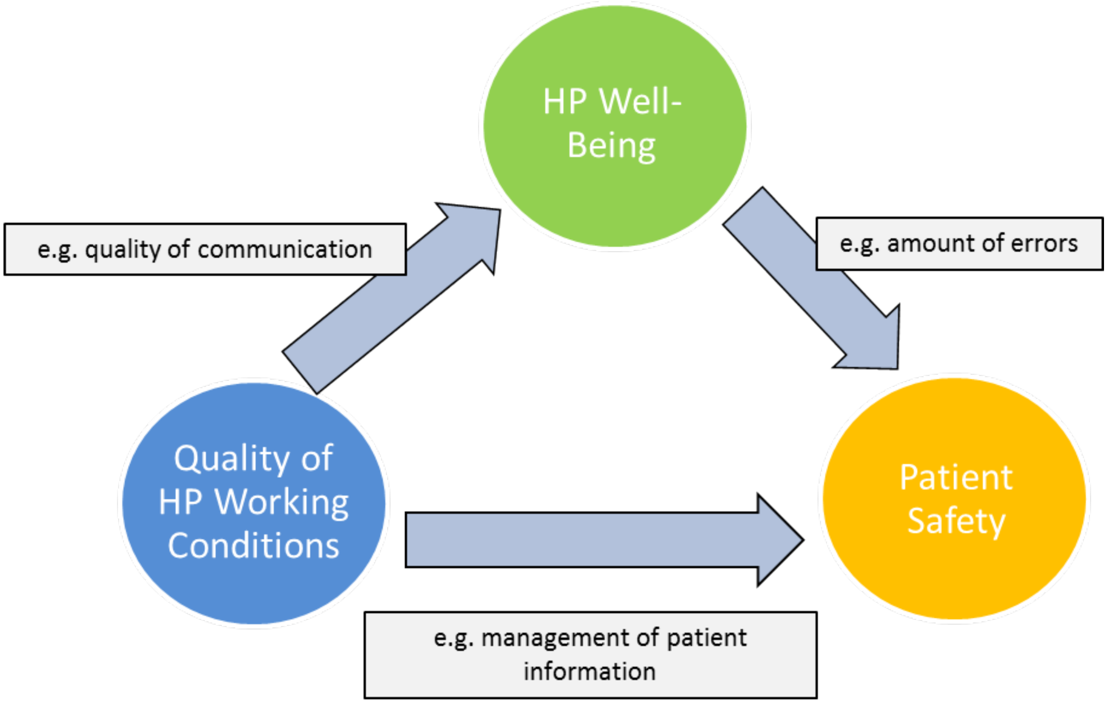

Figure 2. The quality of the working conditions of health care professionals (HP) directly influences both HP's well-being and patient safety. The well-being of HP, for example if they have early symptoms of a burnout, can also have a direct effect on patient safety.

Information Technology in the Hospital Workplace

HIT is already very common in hospitals today (Backhaus & Friesdorf, 2006). While HIT has the very real potential of improving the quality, efficiency, and safety of care (Butler, Payne, Shneiderman, Brennan, & Zhang, 2011; Chaudhry et al., 2006; Garg et al., 2005; Gunningberg, Fogelberg-Dahm, & Ehrenberg, 2009), as well as the working conditions of the HP (Holzinger, Thimbleby, & Beale, 2010), the state of its usability is often in dire need of improvement (Obradovich & Woods, 1996; Wears & Cook, 2006). The most common failures of HIT are the following: That their use is not intuitive enough (Kindsmüller et al., 2009), that they lead to more work for the HP instead of decreasing their workload as they should (Campbell, Sittig, Ash, Guappone, & Dykstra, 2006; Gurses & Carayon, 2007; Gurses & Carayon, 2009; Gurses, Carayon, & Wall, 2009), that they lead to less efficient work (Horsky, Kuperman, & Patel, 2005), and that they are incompatible with the established workflow of the HP (Aarts et al., 2004; Campbell et al., 2006). Not only are these deficiencies in the design of HIT time-consuming and frustrating, they can also lead to clinical errors and can thereby endanger the patient's safety (Bates et al., 1999; Tang & Patel, 1994; Tierney et al., 1987).

It is therefore not surprising that the acceptance of HIT among HP is very low (Garg et al., 2005). Ultimately, if a system is too hard to use or leads to an increase in mistakes, it will be rejected no matter how good the idea behind it might have been or how useful it would have been, had it been usable (Dahl, 2006).

These failures in usability can largely be blamed on the fact that the assumptions of the system designer and the reality of the HP often differ greatly (Koppel et al., 2005; Wears & Berg, 2005; Woods, 1998). The designers do not know enough about the HP and the environment in which they operate and therefore end up creating a system, which does not meet the needs and requirements of the user (Norman, 2002).

To detect usability problems early on in the design process of a system, when changes can still easily be made, it is important to know the user (Johnson et al., 2005). As found by Pressman (1992), fixing a problem when the system is further on in development will cost an estimated 10 times more than fixing a problem in the design phase; If the problem needs to be fixed after shipping the cost is 100 times higher than in the design phase. Unfortunately, often problems with the usability of HIT are only noticed after the system has been installed and the users cannot operate it (Obradovich & Woods, 1996; Wears & Cook, 2006). Fixing a problem at this stage when the system is already installed leads to the original budget assigned for the installation of the new system being drastically exceeded (Pressman, 1992; Lederer & Prasad, 1992). Investing resources early on in the design phase can therefore be an effective way to save costs and to make the introduction of the new technology as simple as possible for the user (Johnson et al., 2005; Mayhew, 1999).

The User-Centered Approach to Designing HIT

Knowing the user is therefore vital to the success of health information technology (HIT). The approach of focusing on the user is called UCD. UCD differs from other forms of design in that it includes the future user of the system in the design process from beginning to end and accentuates the need for systems to be both usable and understandable for its user (Norman, 2002). The requirements, capabilities, knowledge, and constraints of the user are kept in mind throughout the design process and real-life users are brought in to test the system early on (Goa, Massey, Sarrafzade, Selvo, & Welsh, 2007; Norman, 2002). The goal is to create a system that meets the specific needs of the user (Norman, 2002). In the hospital workplace this means, in the words of Johnson et al. (2005) "having the right information in the right place for the right clinician." (p. 76). UCD is an iterative process, which means that prototypes are constantly being redesigned and improved upon in dialog with the users (Vredenburg, Mao, Smith, & Carey, 2002).

A key part of the UCD process is the analysis of the user, his task, and his environment (Johnson et al., 2005; Kreitzberg, 1996; Mayhew, 1999; Shneiderman, 1998). The specific steps taken in these analyses in a practical setting shall therefore be briefly explained in the following section.

User Analysis

The user analysis identifies who the end user is, including demographic data, degree of computer expertise, and any other information that might be relevant for the interaction with the system, which is being designed. For health care systems, knowing the user is especially important since there are many different users with very different goals and levels of expertise who need to interact with the same system (Kindsmüller et al., 2009). There are different methods with which to do a user analysis, including questionnaires or direct observation (Johnson et al., 2005). At the end of the user analysis it should be clear who the user is.

Environmental Analysis

During the environmental analysis, the setting in which the user will interact with the designed system is identified. This includes more direct observations to map out the situation in which the user is when he interacts with the system. Is it a social setting? In that case, the system might need to be accessible to different people simultaneously. Is it a stressful situation where it will be hard to concentrate? In this case, information should be presented as simply as possible to assure that the user will be able to process the information (Johnson et al., 2005).

Task Analysis

In the task analysis, the goals of the user and the tasks, which the user will need to perform to reach this goal are identified. If, as in the health care field, there are many different types of users (doctors, nurses, etc.) who will all need to work with the same system, it is important to do task analyses for all the user groups. The results of the task analysis should yield the information necessary to design a system that meets the specific needs of each specific user group, while still being simple enough to be used by the general user population. The best way of obtaining this information is by direct observations in which the user is watched in his natural working environment (Johnson et al., 2005).

To summarize, the user analysis tells the designer who the user is, i.e. what his skill level is and how often he will use the system. The environmental analysis examines where and under which circumstances the user will work with the system. Finally, the task analysis clarifies what the system will need to be capable of doing and how best to do it, by defining what the goals of the user are (Figure 3).

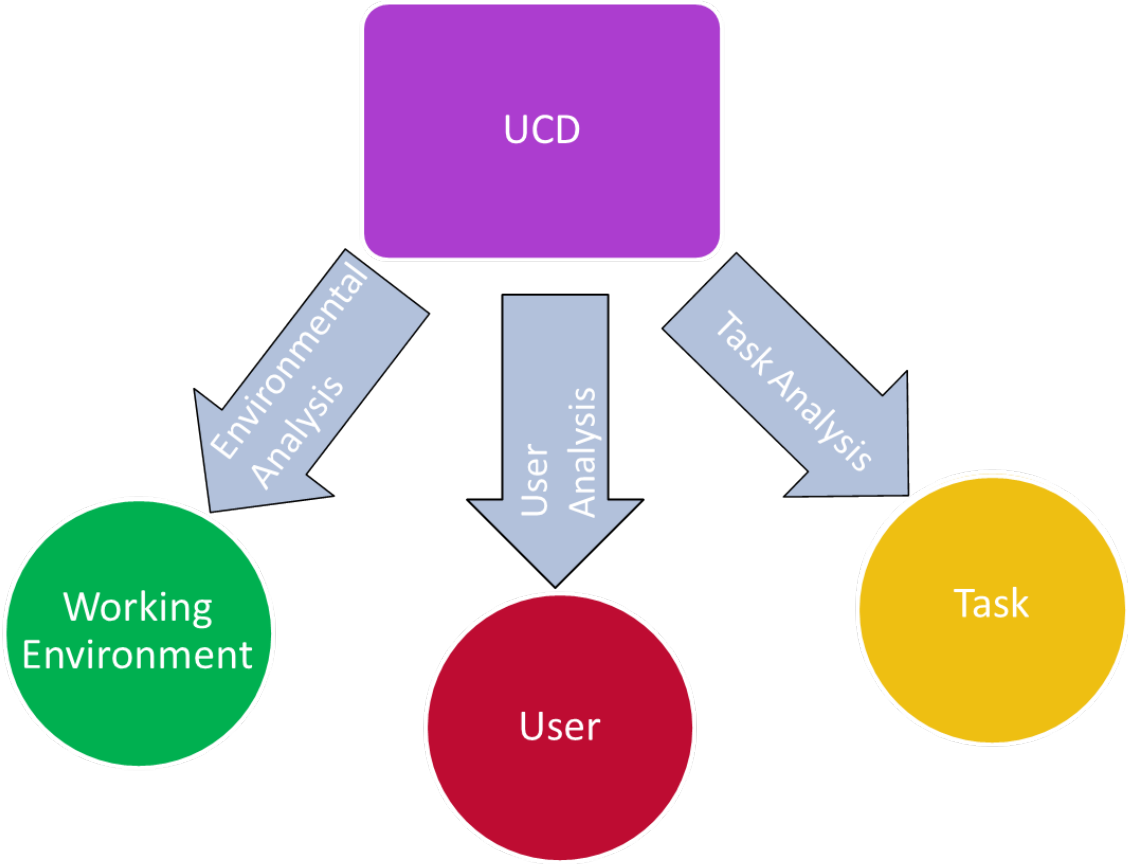

Figure 3. User-centered design (UCD) employs user, environmental, and task analyses to find out who the user is, what he needs from a system, and when and where he will need it.

From Theory to Praxis: Case Studies in UCD in the Hospital Workplace

The account of UCD in this paper has until now been purely theoretical. Therefore it is a valid question to ask whether the user-centered approach has any practical value in solving the problems in the working conditions of the HP and the failures of conventionally designed HIT. Consequently, in this following part three case studies are introduced, which are meant to shed some light on the practical use of UCD in HIT to create or improve systems which assist HP in their daily workflow and thereby help to improve HP's working conditions and patient safety.

Case Study Nr. 1: Improving the Usability of an Existing System

Johnson et al. (2005) used user analysis, environmental analysis, and task analysis to create a user-centered design to salvage a medical system that was at the time barely usable in that its operation was time consuming, error-prone, and frustrating.

In a first step the old system was analyzed. The system in question was a program in which HP could enter the medical family history of a patient. It was mainly designed as a series of forms, which initial usability tests showed to have many usability problems due to, for example, missing important functions and a lack of intuitive labeling.

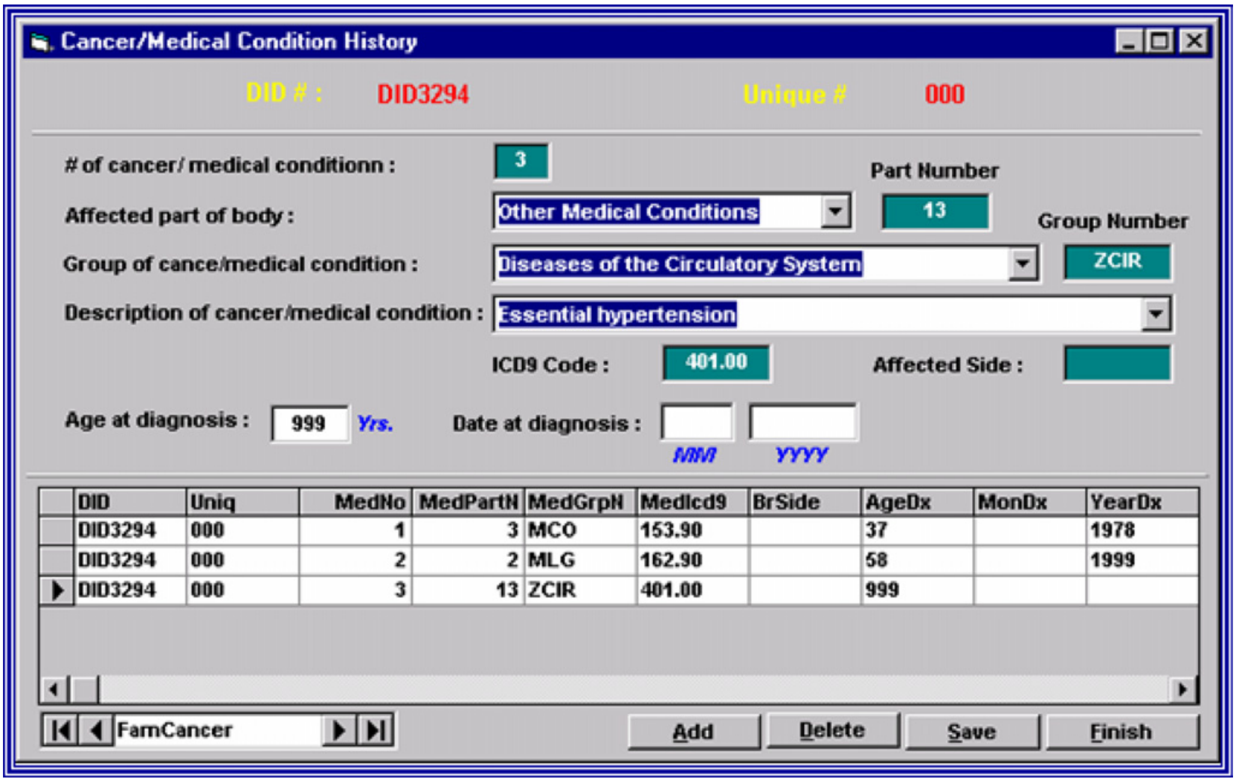

Figure 4. The data entry screen in the original medical system before a user-centered framework was implemented. Clicking on "Finish" without first clicking on "Save" would lead to all the typed-in data being lost. This illustrates a classical example of how a programmer or designer can forget the user's needs or expectations (e.g. that when he finishes working on a form, it goes without saying that he will want to save his work) and only concentrate on the formal structure of his system (e.g. that there is a button to save and a button to finish) (Johnson, 2005).

Figure 4 gives an example of a frustrating problem, which occurred when a user had typed in all the information about a particular patient into a form and wanted to end the transaction. In this situation the user would often accidentally click on “Finish”. This led to the form being closed without further notification. What the user did not know however was that the information typed into the form was not saved unless “Save” had been clicked first. Often, the user only noticed that all his changes had been lost when he tried to print or otherwise retrieve the form. In this case the transaction had to be repeated - without of course again accidentally clicking on “Finish” at the end.

The user analysis Johnson et al. (2005) conducted began with a survey, which they sent to 1252 future users. With a return rate of almost 40% the survey results showed that most users drew pedigrees (a family tree that tracks the phenotypes of the family) by hand, that their work environment was often distractive, and an overwhelming majority used their computer every day. This led Johnson et al. (2005) to decide to design the system with a good deal of direct manipulation (similar to drawing by hand), to be simple to use (to allow the use in a distractive environment), and to be computer-based. In a next step, three existing programs, including the original system, were compared and the best functions of each were noted and included in the concept of the new system.

For this new design the functions and representation were analyzed to find the best way of structuring and representing the different task sets. Subsequently, a paper prototype was created and continually modified using heuristic evaluations and small-scale usability studies. In a heuristic evaluation, the designers put themselves in the position of the user and try to determine how well the user will be able to interact with the system. In a usability study, users are brought in to test the prototype while being observed and giving continual feedback.

When the new system was completed, it was compared with the old system for task completion time, task success and user satisfaction. Results showed that the new system was faster than the old system, that the difference in task success was quite substantial for different tasks which in the old system had shown considerable usability problems, and that user satisfaction was considerably higher for the new system (Johnson et al., 2005).

Case Study Nr. 2: Designing Systems that Simplify Information Accessibility

A wide spread problem in the hospital workplace is that HP need to rely on more and more medical devices that are often very complicated and differ greatly from each other both in layout and general operating philosophy. Furthermore, these devices are not synchronized, which means that HP are forced to type the same information into several different devices. Since HP are often working under a shortage of time, this is a problem that should be avoided (Kindsmüller et al., 2009). The goal should subsequently be to create decision support systems that save time, improve the performance of HP, and thus ultimately increase the quality of health care provided to the patients (Berner & Moss, 2005; Garg et al., 2005; Kawamoto, Houlihan, Balas, & Lobach, 2005; Payne, 2000).

Kindsmüller et al. (2009) present two examples of how using UCD can help simplify the working conditions of HP. The first example is an anesthesia display called “Smart Pilot”, which supports anesthesiologists by presenting a clear overview of the information necessary for them to estimate of the drug dosage necessary to keep a patient sedated during an operation. The second example is a system called “Diagnosis Display”, which assists physicians and nurses in analyzing symptoms and finding the underlying diagnosis of a patient (Kindsmüller et al., 2009).

Smart Pilot. The goal was to create a system that would reduce the workload and support the anesthesiologists in applying the adequate drug dosage to a patient to keep him sedated during an operation. Observations in the OR showed that the anesthesiologists had no interest in an additional device since they already had to monitor many different devices. The situation was so bad that their working space was actually crowded with devices and the anesthesiologists were working around, as much as with, the equipment. The established method of calculating the correct drug dosage was for the anesthesiologists to use heuristic measurements based on the vital signs of the patient read off of these devices. This was potentially problematic since overlooking any important information from any one of the devices could lead to the wrong dosage being calculated. This again could lead to a number of undesired effects for the patient, such as pain and permanent organ damage. It was therefore important that the information needed for the calculation of the correct dosage be presented as clearly as possible.

Figure 5. Smart Pilot comprehensively presented all the information which anesthesiologists needed to accurately calculate the drug dosage needed for their patients. Beforehand, anesthesiologists had needed to monitor several different devices that additionally presented various information that they had no need for. To find the information they were looking for, anesthesiologists were forced to consciously filter out all the irrelevant data – a distraction made unnecessary through the use of Smart Pilot (Kindsmüller et al., 2009).

Through task analysis, the goal of the users was identified as gathering information concerning the patient's vital signs, which they needed to calculate the dosage to keep the patient in the right depth of anesthesia. Using this information, different possible prototypes were sketched and discussed and iteratively revised with the anesthesiologists. In a next step a functioning prototype was created, which showed all relevant information (as discussed with the anesthesiologists) on one monitor (Figure 5). To assure that an overview was possible, different information was displayed in clearly separated boxes (Kindsmüller et al., 2009).

Diagnosis Display. The second system designed was Diagnosis Display. This system was created for physicians and nurses as a decision support system, which would give them diagnosis suggestions according to the symptoms a patient was showing. Usability tests and interviews showed that it was important to the HP to know how reliable a diagnosis suggestion given by the system was, and that a visual presentation was preferred to a numeric one. Therefore, for every possible diagnosis the probability was depicted by varying font size and color (Figure 6, left). In accordance to Berner and Moss (2005), who found that users are more likely to trust and accept a system if it is clear to them how the system came to a particular diagnosis, the diagnosis suggestion was supplemented with the symptoms, which led to the system choosing that diagnosis (Figure 6, left).

A problem that was discovered in interviews with the HP was that while the Diagnosis Display had access to the patient's vital signs such as heart rate or blood pressure, it had no information about other visible symptoms, such as tearing, skin coloration or vomiting, and therefore did not consider them in the diagnosis. HP however were used to relying on observable symptoms and wanted the option of adding these symptoms to the symptoms the Diagnosis Display used for its calculations. Therefore the option of adding clinical observations was implemented (Figure 6, center).

Figure 6. Diagnosis Display was developed in the study by Kindsmüller et al. (2009). Incorporated into an existing patient monitor, it provided information on the patient's state and symptoms, as well as possible diagnoses. It allowed both the option of a quick overview of all possible diagnoses, as well as the viewing of more detailed information of the symptoms these diagnoses were based on.

Since the HP did not want any additional devices in their workspace, the Diagnosis Display was integrated into the existing patient monitor, where it was only visible on demand. The HP however still wished to be notified when the Diagnosis Display had new information to share.

Another challenge was that both nurses and physicians used the Diagnosis Display, but had different wishes as to the type and amount of information offered. The physicians were interested in the diagnosis itself and the information used to come to that conclusion, which they used as an assistance to reaching their own conclusion as to the diagnosis. They found further information about the symptoms to be trivial, since at that point they would already be aware of it. The nurses however were only interested in the specifics of the symptoms, as they based their treatment activities mainly on them, and had no interest in the diagnosis. To deal with these discrepancies in user needs, a compromise was found in which the main information to the diagnosis and symptoms were displayed, and additional information could be viewed by clicking on arrows next to the main information (Figure 6, left) (Kindsmüller et al., 2009).

Case Study Nr. 3: Introducing User-Centered Designed HIT as a Replacement for a Non-Electronic System

Goa et al. (2007) had the goal of developing a health information system, which would help the communication of and the information accessibility for emergency personnel in mass casualty incidents. Mass casualty incidents can be anything from a fire, to a natural disaster, terrorist attack, or military strike. The main problems for HP in a mass casualty incident are in keeping an overview of the situation, locating and marking patients by how critical their condition is, and getting patients to hospitals in the priority order of how much they are in need of immediate medical attention. The existing method of marking patients is by pinning a paper tag with a color showing the gravity of their state on the patient's body. Communication between HP and their incident commanders is established by telephones or hand-held radios. However, this method leads to insufficient communication and information accessibility, and is prone to human error (Goa et al., 2007). This leads to it being very hard for incident commanders to keep an overview of the situation, including where which patients in which states of critical conditions are (Goa et al., 2007).

Before the design process began, users were observed in their working environment and several interviews and questionnaires were used to determine the needs and concerns of the users. The system was to be an electronic tag, which automatically transferred the state and position of the patient to the incident commanders, who could keep an overview of all the patients through a summary panel on their laptop or PDA. By using a UCD process, which spanned four iteration phases of rapid prototyping and feedback from the user groups, a new system was created. To compare the use of the electronic tags with the traditional use of paper tags, a mass casualty incident was simulated with volunteers playing the patients on site. It was found that using the electronic tags allowed for better communication and more information to be collected, while the electronic tagging system was even slightly faster than the paper tagging system. In real-life situations with mass casualties, the use of automatically transmitting tags would allow keeping an overview of a situation, which otherwise would be hard to do, and could prevent high-priority patients from being missed (Goa et al., 2007).

Discussion

In the case studies presented above, three different areas are shown in which UCD can improve HIT and the working conditions of HP. In the first case study by Johnson et al. (2005) an existing system, which was both difficult and frustrating to use, was taken and improved upon using UCD. Changes were made which made the use of the redesigned system more intuitive and less prone to mistakes. As discussed, many existing HIT systems lack intuitive usability and cause mistakes, which can endanger patient safety (Bates et al., 1999; Kindsmüller et al., 2009; Tang & Patel, 1994; Tierney et al., 1987). Using user-centered redesign strategies similar to the ones propagated by Johnson et al. (2005), such as asking the users how they work, comparing different systems or iteratively improving the new system with the help of usability tests, could lead to these systems becoming easier to use and the risk of mistakes decreasing. By making digital information storage and retrieval easier, improvements in the usability of systems could lead to real improvements in the working conditions of HP, by assisting their workflow and helping them save time. By making the use of the system easier and less frustrating, the job satisfaction and the well-being of HP could be increased. By reducing the amount of errors made, improved usability could furthermore lead to improved patient safety.

In the second case study presented, several different information systems were incorporated into one comprehensive display. Through this approach the working conditions of the HP could be simplified and their workflow adequately supported. While beforehand HP had difficulties sorting out the important from the unimportant information, these displays directed the HP’s focus to the important information, while still allowing them to access any additional information they wished to see. As discussed, an inadequate structuring of information in the hospital workplace complicates the HP’s working conditions by making the access of important information more difficult (Backhaus & Friesdorf, 2006; Kindsmüller et al., 2009). By designing systems in a way which allows for better management of patient informatoin and gives the HP the information they need in a simple and comprehensive manner, the working conditions of HP could be improved by supporting their workflow and assisting them in their decision making process. This could lead to better decisions being made on the part of HP and their overall working quality improving, thereby increasing both job satisfaction and patient safety.

In the third case study presented, information access and communication was improved by designing a new system, which managed information electronically. This system was created to replace a paper and hand-held radio-based system. The new system demonstrated that, when designed correctly, HIT does genuinely have the potential to improve the working conditions and the quality of work of HP by allowing faster and better structured information transfer. The communication between different parties was improved as it became both faster and more complete than in the old system. All parties received the information they needed to do their work and make informed decisions. If applied to other situations in which excellent information exchange is important, such as in the OR, the implementation of UCD communication systems similar to the one designed by Goa et al. (2007) could allow all parties to receive the information necessary for them to make accurate decisions. Working conditions could be improved both through better communication and easier information access. Furthermore, easier information access would also help HP to keep a better overview of situations. Patient safety could be increased because more accurate decisions could be made due to improved information access.

As for stress factors related to difficult working conditions, such as time pressure and heavy workloads, the simpler and often faster UCD systems would allow for more efficient information gathering and communication. This should also help to reduce time pressure and workload by cutting the time needed to complete a task. Moreover, having good communication and being allowed easy access to information should assist the HP to feel both more part of their team and more in control of their work. Both of these feelings are important buffers against stress and can substantially improve well-being and decrease the risk of burnout (Mills et al., 2008; Wauben et al., 2011). This again, as discussed earlier, can improve both the quality of work of HP and the safety of their patients (Halbesleben et al., 2008; Spence et al., 2006; Teng et al., 2010).

All three approaches of UCD for HIT could be used both to improve the information systems with which HP constantly interact and to facilitate overall information access and communication, also in settings in which until now HIT has not yet been applied. Thus, the working conditions in which HP operate as well as their quality of work and well-being as well as the safety of their patients could be substantially improved (Figure 7).

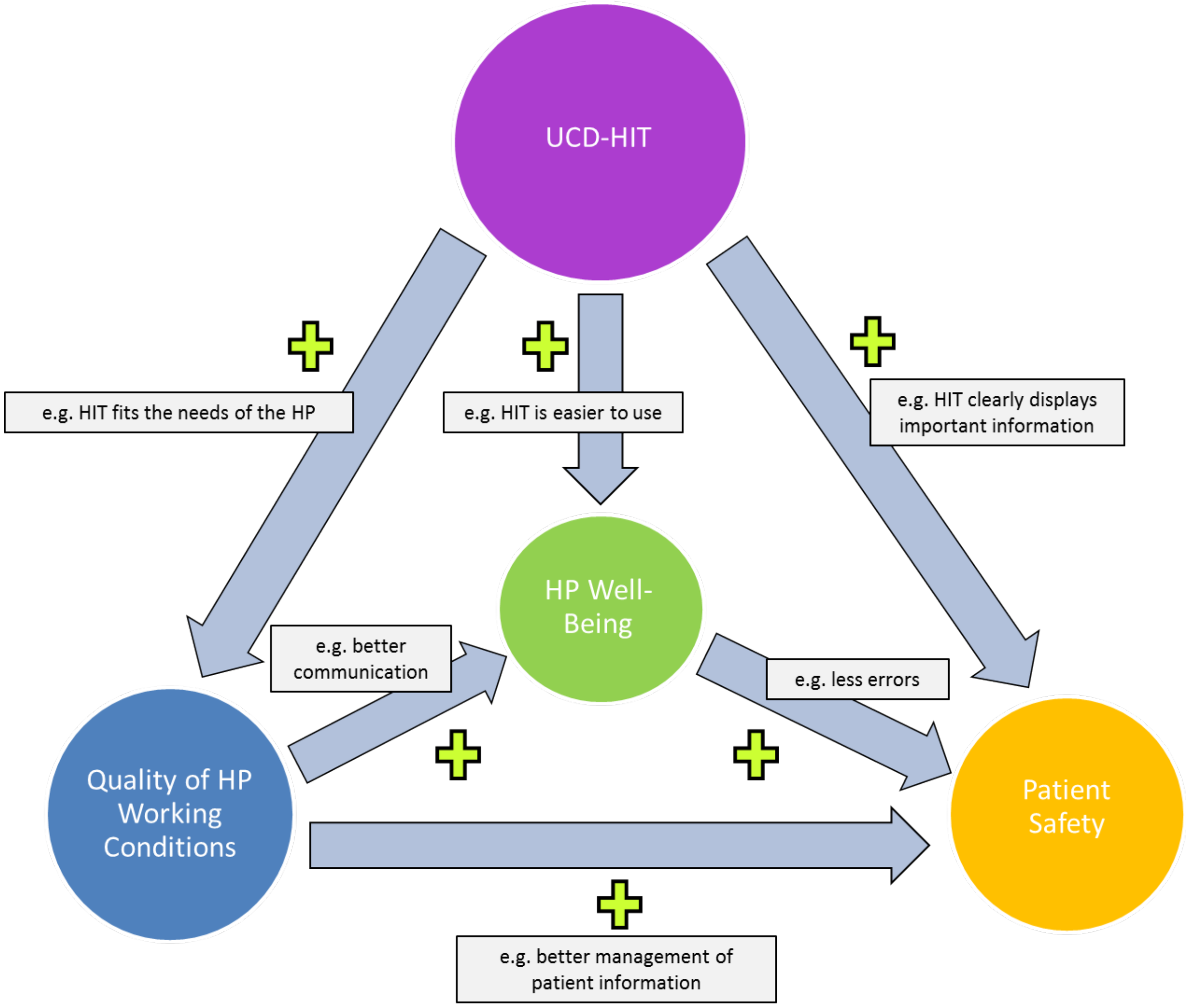

Figure 7. This conceptual model provides an overview of the effects of implementing UCD-HIT (user-centered designed health information technology) on the medical working environment. The examples illustrate the direct and indirect ways in which UCD-HIT can improve HP's (health care professionals) working conditions and well-being and the safety of their patients.

Limitations of Case Studies

There are, however, limitations as to the generalization of these case studies. The nature of case studies in itself is that they examine a very specific situation in detail but cannot make any assertions that go beyond what was observed in that situation. So to conclude upon the basis of these case studies that UCD can improve the working conditions and well-being of HP and the safety of their patients in any case would be unwarranted. To make such a statement it would be necessary to do meta-analyses of a large number of case studies, in which HIT had been designed with a user-centered approach. It would also be necessary to include control groups and do regular check-ups to be certain that the effect is permanent. Sadly, no such meta-analyses appear to exist, perhaps because of the substantial time and costs that would be necessary to conduct them.

There is however evidence that UCD can improve the usability, efficiency, and safety of information technology systems across a broad range of areas, including the medical domain (Cato, 2001; Norman, 2002; Vredenburg et al., 2002). There are also studies that have shown that improving the usability and efficiency of systems or ease of information access can improve working condition factors of HP such as communication and sense of control (Goa et al., 2007; Haynes et al., 2009; Speroff et al., 2010). Furthermore, a growing body of evidence points to the importance of the working conditions of HP for their own personal well-being, their quality of work and therefore for the safety of their patients (Haynes et al., 2009; Von dem Knesebeck et al., 2010; Kowalski et al., 2010; Rutledge et al., 2009; Spence Laschinger & Leiter, 2006). Additionally, even if they are not generalizable, the results of the case studies presented do show that UCD can make significant improvements in several different areas of the medical workplace (Aziz, 2004; Goa et al., 2007; Johnson et al., 2005; Kindsmüller et al., 2009). In the absence of the large-scale meta-analyses, which would be needed to make the direct connection between UCD and HP well-being and patient safety, these studies support the concept that UCD is a promising approach to improve HIT for the benefit of both HP and patients.

Future Outlook: From the User-Centered Design to the User's Design

A question for future research in improving HIT is the question of when it is actually in the best interest of the user to give him a completely new system. Until now, this thesis has worked under the assumption that because HIT has the potential to improve certain aspects of the working conditions such as information access or communication, it is always better than older non-electronic systems. UCD, however, through steps such as user, task or environmental analysis, allows the awareness that the optimal system must do more than just perform a task. It must also fit into the user's workflow. It must not only be the best system for doing the task but also be the best system to fit into the user's environment and the system which best suits the user himself. The most efficient system is of no use to the user if he does not have the skill to use it and the most ingenious device is useless when it does not fit the environment it is intended for. It has been observed that, when necessary, HP are very good at creating their own systems, which optimally fit their needs and the parameters of their environment (Gurses, Xiao, & Hu, 2009). For example, nurses observed by Gurses et al. (2009) had created an information system in the form of a clipboard which contained printouts of all the information that they needed to do their work. The fact that it was paper-based and not computer-based made the clipboard light and easily editable - the main feature necessary for any system the nurses would need in their mobile, unpredictable and busy working environment. This system was optimal for that specific working environment. However, it took a long time to compile, as the information which it contained needed to be accessed out of several different information systems. To improve the whole process of accessing information for the clipboard and then retrieving it in the mobile work environment, in this case would mean optimizing the information systems to best allow access to the information needed to compile the clipboard, but leaving the clipboard itself as it was.

Gurses et al. (2009) argue that at times it is best to focus on creating the tools to assist the user in creating his own system and not on trying to create the system for him. They observed that the needs of different clinicians are so diverse and the specific goals of a single clinician are so constantly changing that it is impossible to create the exact system that will meet the needs of all clinicians or even one clinician over a longer time span. Therefore, they argue, it is necessary not to try to create a system which will meet the clinician's goals but to create the tools which will best support clinicians to design their own system which exactly meets their needs most efficiently (Gurses et al., 2009).

Conclusion

HP work under difficult conditions. HIT has the potential to improve these conditions but only when it is designed correctly. UCD can improve HIT by involving the user in the design process, thereby catching usability problems early on and designing the new system to meet the requirements of the user and his environment. Before new HIT is implemented the question should be asked: What needs to be improved – the system, the tools, or the process? Many HP are not very enthusiastic about learning how to use new systems (Kindsmüller et al., 2009). One aspect of UCD is that sentiments such as this need to be respected and considered when designing new systems. One approach might be to incorporate the new system into an existing system and use design aspects that the user already knows (Kindsmüller et al., 2009). Another could be to make the new system as simple as possible to assure that the time necessary to learn to use the system is minimal (Goa et al., 2007). Another would be to combine many different tools into one system, thereby simplifying the whole process (Kindsmüller et al., 2009). Sometimes the UCD process may reveal that the best system is the system already in use (Gurses et al., 2009). Whatever method is chosen, it should be in accordance with what best meets the needs and wishes of the user. When the HP are asked and involved in the process of creating HIT, they are very capable of contributing to the design process (Goa et al., 2007; Johnson et al., 2005; Kindsmüller et al., 2009). They are thereby an invaluable help in creating the systems which will ultimately not only assist them and improve their quality of work, but will also contribute to the safety of their patients.

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