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## Human factors and ergonomics in home care: Current concerns and future considerations for health information technology

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### Abstract

Sicker patients with greater care needs are being discharged to their homes to assume responsibility for their own care with fewer nurses available to aid them. This situation brings with it a host of human factors and ergonomic (HFE) concerns, both for the home care nurse and the home dwelling patient, that can affect quality of care and patient safety. Many of these concerns are related to the critical home care tasks of information access, communication, and patient self-monitoring and self-management. Currently, a variety of health information technologies (HITs) are being promoted as possible solutions to those problems, but those same technologies bring with them a new set of HFE concerns. This paper reviews the HFE considerations for information access, communication, and patients self-monitoring and self-management, discusses how HIT can potentially mitigate current problems, and explains how the design and implementation of HIT itself requires careful HFE attention.

### Keywords

Health Information Technology; Home Care; Human Factors; Work System

## 1. Introduction

Home nursing care is a diverse and constantly changing industry that has witnessed significant growth in the last few decades [43]. In home nursing care, patient care activities focus on enabling patients to assume responsibility for self-monitoring and self-management through teaching, supporting, goal setting, and modeling decision-making.

As the industry grows, there is increasing demand for innovations in nursing care delivery. These demands arise from a variety of sources. For example, sicker patients with greater care needs are being discharged to their homes to assume responsibility for their own care with fewer nurses available to aid them. Home care patients face significant demands for regimen adherence, as well as monitoring and interpreting related signs and symptoms. These activities create significant challenges for these patients and the nurses who deliver their care.

In addition, there exist significant problems and issues related to human factors and ergonomics (HFE) in the home nursing health care organization (structure) and the care delivery process. Such problems often arise because of mismatches among the five elements of the system: 1) persons (e.g., nurses' and patients' characteristics), 2) task and job design (e.g., task complexity, availability of resources such as time, staffing, information), 3) tools and technology used (e.g., order forms, medication lists, computing technologies and Web sites, blood pressure monitors), 4) the environment (e.g., space and lighting in patients' homes), and 5) organization characteristics (e.g., the structure and culture of the home care nursing organization, nurse practice models, care policies) [9,31]. For instance, nurses must cope with a nursing shortage, insufficient information, inefficient communication, and limits on reimbursement in their jobs, all which require that nurses increase both efficiency and effectiveness in their care strategies simultaneously. Indeed, the problems of insufficient staffing and information and resources and excessive workload all contribute to stress and pressure among nurses and compromise patient safety [35,38,56].

Moreover, there exist a number of concerns in providing nursing care for home care patients such as a lack of ability to track patient's health and hospitalization history, a lack of readily available knowledge in specialty areas, a disconnect in communication among nurse team members, other disciplines, and patients, and a limited amount of time to provide complex patient care [26,35,42]. These problems related to inadequacies in information access and communication, make it more difficult for the nurses to make appropriate clinical decisions, and can lead to frustration or lack of control for nurses [26].

One innovation, health information technology (HIT), designed to address these HFE concerns, promises to improve the processes, quality, and safety of home care nursing, and the performance and job satisfaction of nurses [4,6,10]. Amid growing concerns about safety issues and HFE problems in home nursing care, HIT is at the heart of many of the solutions proposed to address these problems. For example, Gassert and Bolton assert that HIT can provide effective and efficient methods of communication and point of care information and resources for patients and nurses [21]. Thus, HITs have the potential to solve many of the HFE problems of information access, communication, and patient self-monitoring and self-management. Effective use of HITs can also facilitate nurses' performance and workflow and in turn to reduce their workload by providing point of care resources." [2]. The introduction and use of such technological innovations promises to positively impact the technical, logistical, and professional dimensions of nursing practice.

## 2. Objective

Although HITs have the potential to mitigate the problems of information access, communication, and patient self-monitoring and self-management in the current home care system, other HFE problems can emerge in relation to the introduction of these technologies [31]. As such, the objective of this paper is threefold. First, this paper describes current HFE issues and problems in home-based nursing care. We acknowledge that there exists a myriad of HFE issues in the home care setting (e.g., patient lifting, carrying); however, this paper focuses on information access, communication, and self-monitoring and self-management as they are among the primary requirements for nurses and patients in the home care setting. Second, this paper discusses the use of HITs to address those home care issues we identified. We recognize that many other solutions exist, but HIT is currently being widely touted as *the solution* to quality and patient safety problems and its history is shorter and its impact is less understood. Third, this paper illustrates other HFE problems that arise from the introduction and use of the technology, and possible ways in which these problems can be addressed.

### 3. Human factors and ergonomics issues in current home nursing system

Information access, communication, and patient self-management are three essential aspects of the home care delivery process [10] and there are many HFE problems and issues associated with them. These problems often relate to a poor fit among the structural elements of the care system explained in Section 1 [9,31,58]. Poor fit among these system elements can influence the processes of care and subsequently the quality of care delivered and patient safety [9,31,58]. In this section, we describe the current practice of the three fundamental home care aspects, information access, communication, and patient self-monitoring and self-management, and their HFE issues.

#### 3.1. Information access

Information access plays a key role in supporting clinical nursing practice. In home care, the information needed usually includes the patient's health condition and the proper use of prescribed medications and medical equipment [14,37]. For instance, a patient with a history of cardiac problems and the nurse caring for that patient need information about proper dosage and administration of medications, diet management, and sodium intake control. The information is generally presented in a printed or verbal format. Nurses provide patients with written information on the types of food to avoid and how to perform relaxation activities, etc. Nurses also verbally field a wide range of questions regarding domestic, health, social, and family issues as well as provide information on wound care, fluid intake, and when to call for emergency services [13].

Several problems exist with the design of the current practice of information access and exchange in home care. Many patients are discharged from hospitals quickly once their acute conditions are stabilized [35]. Because of that, patients may receive inadequate education or insufficient, incomplete, or inaccurate pre-discharge self-management instructions or information, or they may fail to remember essential information needed for self-care when they return home for recovery [6,17,52]. As a result, home care nurses often need to spend a fair amount of time educating patients about self-care without being provided sufficient time or resources to do so [10].

Also, because patients are often confined at home and may feel isolated from the community [37], they tend to rely heavily on care providers for meeting their information needs. These challenges result in two difficulties: 1) patients may only access information when the care provider is present and 2) there is a heavy burden on the home care nurse to meet all of a patient's information needs. Given the wide range of questions asked by patients, and the shortage of experienced nurses, home care providers are often ill equipped to meet this need. At present, many home care nurses rely upon the Yellow Pages, personal directories, care-services-related directories, or referred patients to community care organizations to answer unfamiliar questions [13].

#### 3.2. Communication

Communication is another key aspect of home care. Currently, communication between home care nurses and other health care providers (e.g., physicians, pharmacists, occupational therapists, physical therapists, nutritionists) occurs primarily by telephone, fax, or through review of patient records. Medication regimen clarification, clinical judgment support, and provision of clinical action recommendations are examples of communication topics [45].

The current design of the home care delivery does not always allow effective and efficient communication among providers. However, adequate information access and exchange in a timely manner often relies on good communication. The current communication modes

(telephone, fax, patient care record review) can cause 1) delays in transmitting and/or receiving information due to difficulties in contacting the other person or department and 2) breakdowns in communication pathways resulting in lost or erroneous communication. As a result, information may be difficult to access and unavailable at the time of need [45]. Moreover, inefficient communication can be burdensome to providers. For example, in telephone communication between nurses and physicians, physicians are often difficult to reach by phone calls and do not return calls in a timely manner [34,45,55]. Waiting for return calls and placing repeat calls is a major burden for home care nurses in terms of time and workload [8]. Breakdowns in communication pathways could cause delays in resolving clinical nursing issues such as medication problems [45].

### 3.3. Patient self-monitoring and self-management

Another key element of home care is patient self-monitoring and self-management. Because of early hospital discharge [35], patients often rely on home management strategies that include both self-care (e.g., monitoring and appropriately responding to their own vital signs and symptoms) and nursing care provided by home care nurses. Nursing care delivery for home care patients often includes multidisciplinary care coordination following evidence-based protocols, monitoring or surveillance (e.g., patients' body weight, blood glucose level, pulse rate, temperature, oxygen saturation, blood pressure, etc.), clinical knowledge and decision-making, and teaching of patients, families, and other caregivers.

Within self-care, patients' methods for self-monitoring, self-management, and health record keeping may be highly variable. Some patients may not keep records at all; others may meticulously keep records on a single-purpose calendar [40]. The range of self-monitoring and documentation behaviors may be anywhere in between these two extremes. For instance, a series of post-it notes or scraps of paper kept in many places is a frequently observed method [40]. This lack of a common self-monitoring method can cause difficulties for nurses trying to determine when the patient last weighed him or herself, for example. When this occurs, the nurse may have to repeat an assessment that the patient has already completed. Frequently, home care nurses have a heavy caseload and such unexpected or unnecessary events delay the subsequent visits to his/her other patients.

In summary, inadequate information access and exchange, ineffective and inefficient communication mechanisms, and problems with patient self-monitoring and self-management all can influence providers' physical, cognitive, and behavioral/social performance in the care process. Performance affected can relate to patient condition and situation assessment, decision making and selecting appropriate clinical actions, perceiving and interpreting critical information, problem solving and developing care plan, coordinating and integrating of other home care nurses' information, providing interventions, evaluating patient outcomes, and the nurses' overall job motivation, satisfaction, and interpersonal communication.

## 4. Health information technology use in home care

Researchers have been developing various Web-based health and decision support systems that allow patients, their caregivers, and their home care nurses access to a Web site that includes self-monitoring tools, information, and communication utilities. Self-monitoring tools consist of trackers to document ongoing status including weight, heart rate, blood pressure, sodium and fluid intake, blood glucose, and daily symptom burden. Information sources include the organization's evidence-based care guidelines as well as vendor-provided disease and pharmacological databases. Communication is supported through secure messaging with their health care providers as well as a bulletin board for anonymous patient-to-patient interactions [6,33].

Introduction of such HIT in the home is one way to address the problems and issues discussed previously. To date, although there is a lack of strong evidence about the direct link between the technology use and patients' health outcomes in home care, the technology offers great promise for home care as it enables nurses and patients to acquire assistance with clinical decision making, access to medical information, and maintain records of the essential self-monitoring parameters at the point of care and remote sites. Indeed, studies have shown that consumer HIT has the potential to help facilitate the care process and ultimately improve patient health outcomes, well-being, quality of life, and independence [18,23]. For example, Brennan's and Gustafson's research teams from the University of Wisconsin-Madison developed computer-based health support systems to provide patients with better access to information and resources for self-care. Their research demonstrated that self-care with the application of health technology led to time reduction in ambulatory care visits and a reduction in hospitalizations [23].

An example of other health innovations that support information access and exchange and patient self-management at home are automated monitoring tools (e.g., HomMed and other home monitoring systems) [53,54]. By connecting themselves to a peripheral apparatus such as a scale, thermometer, pulse oximeter, or sphygmomanometer, patients are able to send clinical information to remote health care providers. Health care providers can then monitor and follow up on the data received; a nurse can advise the patient to seek professional help if it is warranted. Use of telehealth and telemedicine technologies provide patients and nurses with a means for information exchange at the point of care – where it is needed and at the time that it is needed.

Technology also can be used as a means for aiding patients to look beyond themselves, their family and the traditional health care system for information. For example, a videophone network can be used to create a peer-support network by connecting a patient to other patients [51]. This technology can also be used to connect patients to distant family members [50]. Similarly, electronic bulletin boards can be used to encourage information sharing among patients suffering from the same condition and dealing with similar health care challenges [7].

Finally, the use of HIT can be a solution to many of the communication problems in home care. In home care, nurses or therapists at the point of care often need to contact and communicate with other providers at remote sites for information or consultation. Since computers or Web-based health support systems can integrate, store, retrieve, and convey data (e.g., vital signs, medication information, test results, diagnostic medical actions), the need for time-consuming interpersonal communication among providers for acquiring information can be reduced. Some HITs are designed to offer possible explanations of patients' problems and propose potential solutions/courses of action for managing the problems [41]. In addition, HIT can be used to promote the completeness, legibility, and availability of the data for supporting home care nursing practice.

## **5. Human factors and ergonomics considerations for designing and implementing health information technology**

HFE considerations should be taken into account when designing and implementing HIT for home care. Furthermore, the technology should not be introduced into the practice of home care nursing without consideration of its effect on a home care provider's and patient's work system [22]. In the following sections, we analyze the potential HFE problems that could emerge due to the introduction of HIT into home care and possible solutions to these problems. The analysis follows the five elements of a work system according to the University of

Wisconsin-Madison – Systems Engineering Initiative in Patient Safety (SEIPS) model: people, tasks, tools/technologies, environment, and organization [9].

### Technologies and tools

Relying on electronic instead of written sources of information could be problematic if sources are designed without considering HFE issues. For example, elderly patients may have difficulty reading electronic sources because of the small size of the font, irrelevant or excessive use of information and graphical representations, or the colors used on the Web site. Challenges can also arise if the technology is not made with a user-friendly design. These difficulties in using technology can be magnified with the use of electronic bulletins boards and telehealth technologies in which patients and caregivers are expected to not only read the information presented but also to interact with the technology (e.g., perform a visual search and pattern match while using a mouse and keyboard).

Guidelines and principles exist to improve the match between technology interfaces and users' needs and characteristics. These guidelines and principles are available to help designers create an interface design in which the users can use the system effectively, efficiently, and safely. One of the most well-known human factors design concepts is usability engineering [44]. Nielsen emphasizes the importance of usable interface design. According to Nielsen, usable interface promotes learnability, efficiency, memorability, errors reduction ability, and user satisfaction [44]. Nielsen also advocates that all user interfaces should adhere to the following usability design principles: 1) use simple and natural dialogue, 2) speak the users' language, 3) minimize the users' memory load, 4) ensure consistency, 5) provide feedback, 6) provide marked exits, 7) enable shortcuts, 8) provide good error messages, 9) prevent errors, and 10) provide help and documentation [44].

Ergonomics and safety problems related to bringing additional equipment and tools into the home for nursing visits could also occur. In a typical visit, home care nurses often have to carry many different devices, tools, and other materials, such as a stethoscope, a thermometer, a glucometer, a pulse oximeter, a laptop computer, a backpack, teaching materials, documents, and other supplies. Heavy equipment, tools, and various education materials could be a burden to nurses because they may be physically challenged in carrying all the equipment and materials into the patient's home. Back injuries or musculoskeletal-related problems could occur when nurses carry excessive number of tools or heavy materials. Attention must be paid to this potential source of injury. Nurses should avoid frequent and heavy lifting of the materials and equipment. They should consider carrying the bare essentials to patient homes for home visits or using wheeled carts to help carry the weight. With the use of technological innovations (e.g., automated home monitoring system), nurses will have to carry fewer devices, equipment, and materials during the home visits.

### Persons

Individuals' level of confidence in their ability (self-efficacy) to use technology is an important factor for facilitating their adoption of health information innovation [15,16,39]. Some home care nurses and patients lack confidence in their skills (e.g., intellectual or manual skills) and knowledge (e.g., general computer knowledge) to use the technology to perform home care tasks [36]. This lack of self-efficacy may be related to computer expertise [16], prior use of technology and computers [16], organization support [12,27], or demographic characteristics [16,39], though these have not been confirmed in home care specifically.

Patients' improper use of the HIT can be caused by lack of information and instructions, inaccurate training by the home care nurses, or cognitive challenges or diminished ability to learn about how to operate the innovation. Therefore, user confidence and skills (e.g., both



patient and nurse) need to be augmented. This can be achieved by providing users with proper training, adequate instruction, and ongoing technical support [36]. Other user factors such as needs, beliefs, mood, etc., should also be considered when we design and implement HITs [29-31].

Since home care patients are also the targeted end-users of the technology, when designing HIT for home care use, patients' characteristics (needs, attitudes, and expectations) and limitations (motor limitations, cognitive limitations, perceptual limitations, external limitations, and general health limitations) must be adequately met and addressed [19,46,48].

## Environment

The implementation of new technologies will change the nature of the physical environment where home care providers work (i.e., the patient's home). The physical environment will also affect how the technology is implemented and used. Considering human factors engineering principles for work environment design is a good practice for improving the interaction between users, the technology, and the environment. Lighting, noise, and thermal comfort are the most common environmental aspects to consider. A room that does not have an appropriate level of lighting, for example, will make using a device (e.g., monitor display) physically uncomfortable and affect task performance and work output [49]. Similarly, a patient will have a difficult time using technology such as a videophone or an interactive telemedicine device with their care providers at a remote site if the technology is placed in a room that is often noisy. A number of HFE handbooks, standards, and guidelines that contain more detailed information concerning work environment design have been developed and can be used for reference [1,3,32,49].

Some safety hazards that could exist in patients' homes will preclude successful and safe use of technology. Dedicated electrical outlets for power supply to the technology may be limited in some patients' homes [20]. Because of the unavailability or inadequacy of electrical outlets, it would not be unusual for electrical strips or computers' power cables to run across the room for the equipment. They are hazardous to both providers and patients who could be tripped by the wiring when they are working or walking around the room [3]. Moreover, children in a home pose risks for proper technology implementation because they may tamper with the equipment, alter the settings, unplug devices from outlets, etc. [20]. The issue of the presence of children (or pets) is also an essential consideration for equipment design for home care use.

Limited space in patients' homes is another issue for HIT designed to implement in the home. For example, a heavy and cumbersome computer monitor, computer chassis, and other peripheral devices may be placed on a fragile or small desk surface; this puts the users at risk because the equipment could fall from the surface. Appropriate placement of the equipment is critical to maintain safety. Moreover, nurses sometimes may have difficulty determining a safe and convenient place to locate their laptop computer and other equipment because of limited space and other obstructions in patients' homes. The patient and the health care technology may be in separate rooms, which would affect the efficiency of technology-enhanced nursing practice care delivery.

Nurses not only need to be alert for environmental hazards, they must also teach and encourage patients and family members to avoid environmental safety hazards. Other personnel such as home health aides, occupational or physical therapists, or social workers may also help to identify and minimize those problems.

## Organization

New technologies may be difficult to implement and use effectively under existing organizational policies and practices. When integrating a HIT into home care nursing practice, it is important to develop protocols and guidelines that specify how and when to use the technology. Moreover, sufficient training, organizational supports, and education for learning how to obtain and evaluate the electronic information and assessing its quality should be provided to both patients and providers [28].

Kaplan and Brennan stated that *“The growth of new information sources and services raises societal and governmental concerns,”* and thus, *“Groundwork needs to be laid to help ensure reimbursement arrangements that do not create disincentives for clinicians to use the new technologies ...”* [28] Moreover, they stated that *“Lack of systematic development efforts, lack of an organizational culture that promotes the use of the Web and Internet services, and lack of clear business plans have resulted in poor interfaces and limited tools on Web sites developed by some health care organizations.”* [28]. Therefore, at the organizational level, a systematic plan as well as an organizational culture that promotes and encourages the use of HIT is needed when developing and implementing such technology [30,31].

## Tasks

Nurses can acquire patients' medical history, vital signs graphs, medication information, problem/diagnoses lists, and other relevant references using the electronically accessible databases at the point of care. However, the database is often based on records generated from physicians, pharmacists, physical therapists, nutritionists, etc. Because of the importance of effective and efficient transfer of patient information among the providers or from the database to nurses and patients, there is a need for formal/standard vocabularies in the database [5,11, 24]. The use of idiosyncratic terminologies in the database is a barrier to development of fully integrated patient-centered information systems and can lead to difficulty in interpreting the information by the home care nurses or the patients [5]. As a result, additional but unnecessary communication between the nurse and other providers is required for information clarification.

Other issues such as task difficulty and complexity, time demand, and task monotony are also potential problems related to the nursing care tasks with the use of technology. For instance, Kossman and colleagues indicated that home care nurses have been facing heavy work load and tight schedules; however, the implementation of a new HIT would create additional stress (in terms of task difficulty and time demand) for them [36]. In the project reported by Kossman and colleagues, home nurses' clinical practice is supported with the use of a Web-based technology. However, nurses felt uncomfortable using the technology and perceived its use as a burden to their patients. Their research team made efforts to address these challenges such as increase communication between the research team and the nurses, provide organizational support, and invent strategies to promote the use of the technology.

## 6. Discussion and Conclusions

Advanced information technology has the potential to mitigate the problems related to information access, communication, and patient self-monitoring and self-management previously mentioned. HIT is being introduced in home care to improve the nursing care processes in patients' dwellings, and to improve patient outcomes. For example, Web-based health and decision support systems provide users with better access to patients' referral information, medications, and test results; telemedicine offers real time and interactive consultation and augment patients' and nurses' access to physicians or other specialty expertise. Information technology that lists credible information sources related to the patient's medical condition can serve as a starting place for patients to answer their condition-related questions.



Furthermore, the technology can provide links to answers to other questions that home care nurses know to be frequently asked by patients in the home.

To ensure that this technology is well designed, several HFE considerations to improve product design have been discussed in this paper. Since persons living with chronic illnesses and receiving home care are often older than the general population, it should be noticed that the characteristics and limitations of patients or elderly are also important to consider when creating home-based technology for them. Motor, visual and auditory, cognitive, external, and health limitations all must be taken into account for design [48]. It is beyond the scope of the paper to detail all HFE concerns related to HIT, but the interested reader is referred to HFE design and methods texts [25,32,44,47,49,57].

Furthermore, the SEIPS model [9] and its variants [31] can be used to understand the scope of HFE issues in a work system. By analyzing a technology's impact on the task, environment, organization, and person, it is possible to uncover the potential problems associated with a work design with or without new technology and ways in which these problems may be mitigated. Some examples, evidences, and perspectives from the literature are included to illustrate this point. Although this paper does not intend to provide exhaustive solution to system design problems, we present the use of a framework to address difficulties that may arise during the introduction and implementation of technology, and provide guidance as to possible solutions.

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