Designing Home Health Technologies For Older Adults: The Human Systems Integration Approach

Cara Fausset and Linda Harley

From intensive care units with dozens of highly trained healthcare professionals to home healthcare in which patients manage their own health, the modern healthcare system spans many users, tasks, and environments. The home healthcare system is vast and variable, depending on the level of care that each person requires. Our goal is to discuss the human systems integration approach for designing home health technologies for older adults. By understanding user abilities and task demands, and how those factors interact within the home environment, designers can develop technologies that positively impact older adults’ quality of life.

For the purposes of demonstrating how the human systems integration approach may be applied to medical device development, the scope of this article has been limited to older adult patients living alone in their homes who need to use a blood pressure monitor.

There is an ever increasing need for health technology to migrate into the home environment. According to the Association of American Medical Colleges, the U.S. is facing a tremendous shortage of doctors and nurses.1 The expansion of healthcare services through the Affordable Care Act, coupled with the growing population of older adults and the large number of primary-care physicians set to retire are cited as contributors to a need for more than 52,000 primary-care doctors by 2025.2 In addition, nursing home costs have risen from an average of $8,280 per patient per year to an average of $57,600 per patient per year in 2002 according to the Centers for Disease Control and Prevention (CDC).3 With costs rising rapidly, an affordable option is for older adults to manage their own health at home.4,5 Properly designed home health technology can be used to deliver medical care (e.g., oxygen, infusion, dialysis) and monitor health status in real time (e.g., blood pressure, glucose, fall detection), potentially saving both time and money that would otherwise be spent in a doctor’s office or nursing home.

The potential benefits of home health technology are numerous. Home health monitoring can alert healthcare professionals to provide proactive care and reduce the likelihood of a hospital visit. Proper health management at home can also reduce the number of days a person stays in the hospital, thereby lowering costs and the probability of contracting a hospital-borne disease.6 Well-designed home health technology can also support the goal of older adults’ to maintain their independence.7,8

By understanding user abilities and task demands, and how those factors interact within the home environment, designers can develop technologies that positively impact older adults’ quality of life.
Bringing health technology into older adults’ homes presents challenges. Older adults may have limited experience or familiarity with technology in general, possibly putting them at a disadvantage when interacting with health technologies likely designed based on existing technology (e.g., touchscreens). Age-related changes in cognition, perception, and physical capabilities exacerbated by illness may also interfere with optimal health technology adoption and acceptance. Moreover, the home environment may not be suitable for interacting with health technology due to factors such as unreliable power sources, inadequate lighting, loud ambient noise (e.g., TV is always on), limited space for operation and storage, and intermittent or no Internet connectivity. Given these challenges, home health technology that is designed without consideration of users’ abilities, task demands, and home environment factors could compromise users’ safety and technology effectiveness.

The human systems integration approach is a conceptual framework used to ensure that all human-related concerns and performance issues are properly addressed. This is a qualitative model created to guide the design process; the design team must determine the quantitative metrics against which success and failure will be assessed. Metrics will vary depending on the users, the technology, and the environment being considered. The human systems integration approach is useful for identifying the requirements and boundary conditions of home health technologies designed for older adults (see Figure 1). If older adults can perform the tasks required to manage and maintain their health within their home environment, the interaction is successful. However, if the task demands exceed older adults’ abilities, the interaction fails. Home health technologies must be functional, reliable, and usable for older adults to accept, adopt, and use in their daily lives.

**Challenges and Opportunities**

In addition to becoming the fastest growing segment of the world population, older adults represent a large proportion of potential home health technology users. This population could benefit greatly from home health technologies that support monitoring and management of prevalent chronic diseases such as hypertension, congestive heart failure, and diabetes. However, older adults often have less familiarity with technology than younger cohorts, and likely have less experience with home health technology than technicians or healthcare practitioners. Additionally, older adults experience age-related changes across cognitive, perceptual, and physical capabilities that are exacerbated by illness.

To design a health technology that can be used successfully by the target population, designers must identify and understand the specific abilities of that population and how that impacts design.

**Figure 1.** The human systems integration approach: a representation of the user-task-environment interaction. When the user's ability equals or exceeds the task demands in the home environment, the interaction will succeed. When the task demands exceed the abilities of the user in the home environment, the interaction will fail.
From Telegram to Smartphone
The range and variability in home health technologies present different challenges for users; therefore it is essential that a task analysis be conducted to fully understand the task demands each health technology places on its users. There are many different types of task analyses that can be conducted, but all analyses provide a systematic way to describe the human interaction with a system. The goal of conducting task analyses is to understand how to match users’ capabilities to the system demands. Important types of information assessed in a task analysis include the following: hierarchical relationships; information flow; task sequence; location; and environmental conditions. A complete system task analysis should include not only the user interface, but should also investigate the ease of storage, portability, professional support infrastructure, and maintenance of the technology, as well as that of educational materials on how to use the technology.

The following high-level task analysis example explores the tasks necessary to use a blood pressure monitor that connects to a smartphone:
1. Connect blood pressure monitor to smartphone
2. Launch smartphone application
3. Place blood pressure cuff around arm
4. Start measurement
5. Wait until measurement completes
6. Read measurement
7. Remove blood pressure cuff
8. Send reading to electronic health records
9. Close the smartphone application
10. Disconnect blood pressure monitor from smartphone
11. Use results to inform future health decisions such as food choices, salt intake, etc.

No Two Homes are Alike
The home environment presents unique challenges because of the unpredictability and the variability of the home environment. A range of characteristics must be considered, from a state-of-the-art senior housing development designed to support aging in place to a 1920s two-story home with narrow doorways, steep stairwells, poor insulation, and dim lighting. Some examples of these characteristics may include:
- Availability of proper infrastructure (e.g., power, Internet connectivity, refrigeration)
- Environmental factors (e.g., narrow doorways, noise, temperature, lighting, humidity, storage space)
- Access to services (e.g., cleaning, maintenance, technical assistance, waste disposal)
- Controlling access to the health technology (e.g., kids, animals, nurses, pharmacists)

Currently, many medical technologies designed for the hospital environment are directly translated into the home environment. However, there are some fundamental differences in the environment between the hospital and home that should be considered, such as availability of trained medical staff to operate the technology, ease of maintaining and replacing faulty technology, and infrastructure. For example, in most hospitals, oxygen lines are built into the infrastructure so as to provide a hookup valve next to the patient’s bed. However, in the home, portable oxygen systems are employed so as to allow the person to move around their home freely. Different environments often result in different design criteria.

The Human Systems Integration Approach
To illustrate using the human systems integration approach, let’s consider Harold. He is 72 and has hypertension and diabetes. Hypertension can cause severe headaches, fatigue, confusion, vision problems, chest pain, difficulty breathing, and irregular heartbeat. Diabetes can cause fatigue, nausea, blurred vision, and neuropathy. His severe diabetic highs and lows cause decrements in his cognitive processing and...
The grand challenge facing home health technology designers is providing technologies that are both safe and easy to use by older adults in the home environment.

<table>
<thead>
<tr>
<th>Factors</th>
<th>Demands</th>
<th>User Ability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wired</td>
<td>False: Fine motor dexterity and strength required to insert connector into smartphone and monitor.</td>
<td>Neuropathy leads to loss of dexterity and inability to complete this task.</td>
</tr>
<tr>
<td>Connection</td>
<td>Low: Knowledge required to know which end of the connector goes into which device.</td>
<td>Hypertension and diabetes can lead to confusion and therefore inability to know what to do for this task.</td>
</tr>
<tr>
<td></td>
<td>High: Visual acuity required to see the connection points in the devices.</td>
<td>The inputs on the phone and monitor may be too small to read for people with vision impairment.</td>
</tr>
<tr>
<td>Bluetooth</td>
<td>Low: Gross movement control to tap the screen of the smartphone.</td>
<td>Neuropathy leads to loss of sensation in fingertips and the ability to sense touch.</td>
</tr>
<tr>
<td>Connection</td>
<td>High: Knowledge required to pair the device to the smartphone.</td>
<td>Inability to know what to do for this task. More demanding than the wired.</td>
</tr>
<tr>
<td></td>
<td>High: Visual acuity required to see the on-screen smartphone information.</td>
<td>The font size may be too small, or the contrast may be too low, for people to read text.</td>
</tr>
</tbody>
</table>

Table 1. A human systems integration example of connection blood pressure monitor to a smartphone.
gies must be functional, reliable, and usable for older adults to accept, adopt, and use in their daily lives. The degree to which designers account for these challenges and adopt the human systems integration approach will support the success of future home health technology design.

**References**


Benchmark It!

Select the web-based benchmarking resource to fit your needs...

**Benchmarking Solutions**

**HTM**

- Designed for healthcare technology management departments, this features over 70 measurements:
  - Staffing levels
  - Cost of maintenance contracts
  - Personnel qualifications and responsibilities
  - Number of devices maintained

**Order code: ABS**
List $850
AAMI member $750

**Benchmarking Solutions**

**Sterile Processing**

- Designed for sterile processing departments, this features more than 175 benchmarking metrics:
  - Budgeting and financial issues
  - Sterilization practices
  - Volume and types of work performed
  - Staffing, qualifications, and much more.

**Order code: SPB**
List $850
AAMI member $750

**Benchmarking Solutions**

**Quality Management System for Medical Devices**

- Helps device companies compare elements of their quality management systems with those of their peers. It features more than 100 measurements covering:
  - RISK MANAGEMENT: Adherence to standards, management involvement, and documentation
  - CORRECTIVE & PREVENTIVE ACTION (CAPA): Issue escalation, CAPA management, and preventive action statistics

**Order code: QMS**
List $1,450
AAMI member $1,100

Benchmarking data can be submitted at the corporate, division, or site level. Developed with input from FDA, AdvaMed, and leading Risk Management and CAPA experts.

Order Your Copy Today!
Call +1-877-249-8226
Visit http://my.aami.org/store