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# The Virtual Hospital: Treating Acute Infections in the Home by Telemedicine

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## Abstract

*The growth and aging of the population of Hawaii mandates a need for more effective utilization of hospital beds. One approach is early hospital discharge and outpatient treatment. However, as the acuity of illness increases, satisfactory outcomes of outpatient treatment may be difficult to achieve. We have utilized telemedicine to closely monitor acutely ill patients with infections, such as community-acquired pneumonia, skin and soft tissue infections, and urinary tract infection, in the home setting. Our treatment paradigm achieved satisfactory outcomes, cost savings, and at the same time resulted in more rapid convalescence than hospitalization.*

## Introduction

Nationwide there were 35 million people age 65 and older in the year 2000. By 2030, this is expected to double<sup>1</sup>. In Hawaii, there were 160,000 residents age 65 or older in the year 2000. This number is projected to grow to 309,000 by 2025.<sup>2</sup> With the growth and aging of the population, there will be an increasing need for acute care hospital beds. Alternative strategies to hospitalization must be developed to care for patients with, among other things, common infections such as community-acquired pneumonia (CAP), skin and soft tissue infections (SSTI), and urinary tract infections (UTI).

Treating patients at home is one alternative that can reduce the need for hospital beds. In order to care for more seriously ill patients in home settings as opposed to hospitals, we need to be able to monitor patients' vital signs and "look in on them" as we would if they were hospitalized. Telemedicine makes this possible by providing real-time transmission of vital signs and audio-video contact between patients in their homes and clinicians in the hospital. This "virtual umbilical cord" simulates the normal physician-nurse-patient interaction in the hospital and provides closer home monitoring of patients who might normally be hospitalized.

The majority of telemedicine use in the home has been directed at chronically ill patients with congestive heart failure, emphysema, and diabetes. This approach has proven to be cost effective, reducing the need for hospitalization and emergency room visits.<sup>3,4</sup> Using telemedicine in the home, the average number of

daily home-nursing visits can be increased from five actual visits to fifteen televisits.<sup>3</sup> Telemedicine can also be used to care for acutely ill patients in remote locations.<sup>5</sup> We have utilized this same technology in a pilot trial, which monitored acutely ill patients with infections in the home setting.<sup>6</sup> To the best of our knowledge, no one else has attempted this to date. We report here further results from this study.

## Methods

Equipment was purchased from American Telecare, Inc (Minneapolis, MN) and consisted of one Aviva Tower central station and four Aviva 1010 XR patient stations. We kept one patient station in reserve and therefore could treat a maximum of three patients at one time. The telemedicine connection between the patient station in the home and the central station in the hospital was through POTS (plain old telephone service) lines. The telemedicine team consisted of a physician (LE), two nurse practitioners (PK and MM), an IT consultant (EB), and a project coordinator (CY).

Patients were referred for telemedicine in the home, either from the emergency room or, if admitted, from the hospital, and were screened by the physician for inclusion in the telemedicine program. Before considering discharging a patient from the hospital on telemedicine in the home, we evaluated their Karnofsky performance score<sup>7</sup> and Charlson Comorbidity Index.<sup>8</sup> For example, if a patient had a relatively severe case of CAP with a high pneumonia severity index (PSI),<sup>9</sup> but had a high performance score and few comorbidities, he might be considered a candidate for treatment by telemedicine in the home. However, if he had a relatively less severe case of CAP, but had a low performance score and multiple comorbidities, he might be excluded from treatment by telemedicine. If the patient met the inclusion criteria (Table 1), the nurse practitioner discussed the trial with the patient and family members. It was extremely helpful to have a least one face-to-face interaction with the patient and their families prior to their discharge from the hospital on telemedicine in the home. This assisted us in gaining their trust and provided a comfort level in their acceptance of telemedicine in place of hospi-

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Table 1.— Criteria for Treatment of Patients with Telemedicine in the Home
Patients must have a domicile with a second person to assist the patient (usually family or a friend).
Patients must be ill enough to ordinarily require hospitalization, but have a low predicted 30-day mortality rate.
Patients must not have sepsis syndrome or the need for intensive care monitoring.
Patients with CAP are excluded if they have a mild (Fine Class I) or life-threatening (Class V) CAP. <sup>9</sup>
Patients with SSTI are excluded if they have mild SSTI (Eron Class I), or if they have sepsis syndrome or life-threatening (Class IV) infection. <sup>15</sup>
Patients with UTI are excluded if they have uncomplicated pyelonephritis or if they have an obstructed ureter or sepsis syndrome.
Patients with bacterial endocarditis (BE) are excluded if they are hemodynamically unstable, or if they have embolic episodes.

Table 2.— Types of Patients Treated by Telemedicine in the Home
A 78 year old male with leukemia and an absolute neutrophil count of 400/mm <sup>3</sup> developed bibasilar infiltrates, a temperature of 102° C, and an oxygen saturation of 90%.
A 48 year old female with metastatic carcinoma of the breast and a white blood cell count of 2,500/mm <sup>3</sup> developed cellulitis extending from her left hip to her axilla.
A morbidly obese 53 year old male with a mechanical aortic valve prosthesis developed high grade enterococcal urosepsis (5 of 5 sets of blood cultures and a urine culture positive).
A 66 year old male with severe aortic insufficiency and a previous right nephrectomy for a renal cell carcinoma, developed <i>Gemella</i> endocarditis with a vegetation on his aortic valve.

talization. The patient and family members were typically anxious over this new technology and needed reassurance that they would be monitored closely in their home environment. It also allowed us to obtain a face-to-face baseline history and physical exam.

After screening, they were asked to provide written informed consent, if they were found to be acceptable for treatment by telemedicine in their home. Reasons for exclusion included an unsuitable home environment, such as homelessness or living alone, an inability to learn self-administration of intravenous antibiotics, and a lack of suitable phone lines in their house. In four cases patients refused to be treated by telemedicine because of a lack of familiarity with, or fear of, computer technology.

Once they agreed to treatment by telemedicine in the home, a member of the telemedicine team met them in their home to set up and instruct them or a family member, friend, or neighbor, in the use of the equipment. The first televisit was then conducted between the patient in the home (in the presence of the telemedicine team member) and a clinician at the central station in the hospital (either a physician or a nurse practitioner trained in the management of these types of infections). After demonstrating a televisit, the telemedicine team member in the home observed the patient's technique. Once patients mastered the application of the blood pressure cuff to their arm, the stethoscope to their chest, and the pulse oximeter to their finger, they managed subsequent visits faultlessly. Problems encountered involved suboptimal lighting or excessive movement of the patient, which resulted in fragmentation of images due to excessive pixelation. The best lighting was indirect without any back-lighting.

The initial televisit usually lasted for one hour, subsequent followup visits 15 minutes, during which time patients in their home and the clinician at the central station were able to see each other and converse. The clinician at the central station was able to determine the patients' clinical status by auscultating their lungs, and monitoring their blood pressure, heart rate, respiratory rate, temperature, and oxygen saturation. With the loss of face-to-face encounters, strategies for meeting other family members and pets and for commenting on the patient's home surroundings while conducting televisits, assisted in gaining the patients' and the families' confidence and trust. Most patients televisit once daily, but for patients with more

severe illnesses, televisits can be conducted several times daily. When patients improved to the point where they would normally be discharged from the hospital, patient stations were removed from homes. Should a patient's clinical status have deteriorated at any time, he was instructed to either call a member of the telemedicine team or return to the hospital.

#### Results of a pilot trial:

We have reported the outcomes of a trial of telemedicine in the home in which we treated 25 patients<sup>6</sup>. The types of patients that were treated are illustrated by the four examples in Table 2. We compared patients treated by telemedicine in the home in a case control fashion to a comparable control group of hospitalized patients. While the large majority of patients in each group were cured, those treated with telemedicine in the home recovered at a more rapid rate, as judged by their earlier return to their normal activities of daily living.

Through the use of telemedicine, we were able to accomplish five things.

- The patient could be monitored several times a day, as if he were in the hospital.
- The patient was reassured by maintaining audiovisual contact with his health care providers.
- More efficient bed utilization was accomplished by discharging hospitalized patients earlier than would otherwise have been possible, and in some cases avoiding hospitalization altogether.
- The patient felt more comfortable at home than in the hospital.
- Based on our prior experience<sup>6,10</sup> and that of others,<sup>11</sup> patients who were managed as outpatients returned to their normal activities of daily living more rapidly than comparable patients who were hospitalized.

### Technical problems:

We experienced several problems that must be overcome before telemedicine in the home can be widely deployed. First and foremost is that of technical problems, such as poor video images and freeze-ups. This problem is caused by low bandwidth (a measure of the amount of information that can be transmitted over a telecommunications line) of POTS. Equipment offered by the major home telemedicine vendors is, for the most part, POTS-based. The low-bandwidth of POTS connections did not consistently support the minimum telemedicine requirements of two-way video and audio connections plus one-way data transmission of patients' vital signs. With the broadband connections via cable, DSL, and Wi-Fi, that are becoming commonplace, there is now sufficient, available bandwidth to allow for higher-quality video and audio connections that could vastly improve telemedicine. Moreover, once the telemedicine vendors adopt the Internet protocol, then there will be even better flexibility in terms of mixing and matching devices, using different types of connections, and more easily moving the clinician's station between sites, such as the clinician's home and office.

The established telemedicine vendors have been slow to embrace the rapid technical advances in telecommunications of the past five years, and computer equipment vendors, whose products use the latest broadband and Internet protocol technologies, have generally been reluctant to enter the telemedicine marketplace. At the end of the day, it will be up to us, the telemedicine equipment buyers and users, to pressure vendors to move beyond POTS-based equipment, and to partner with them to develop and test new equipment.

### Patient acceptance:

Patient reactions to telemedicine in the home may differ depending on age, gender, educational level, family support, and cultural factors. This may be especially true in Hawaii where there is such a diverse cultural representation. Telemedicine may not be appropriate in certain cases based on these considerations. Two examples of this are as follows: elderly patients who feel safer in a hospital environment than in the home;<sup>12</sup> individuals of Philippine or Hawaiian descent who are more accepting of hospitalization and reluctant to receive treatment by telemedicine in the home.

Care-providers may in certain cases be dissatisfied with telemedicine in the home compared to hospital care for their wards.<sup>13</sup> They may be unwilling to bear the entire burden of caring for a patient. It may be necessary to provide respite workers in selected cases to shop, cook, clean, bathe, and otherwise provide companionship for certain patients. This relieves a care-provider from shouldering the entire burden of a patient's care. However, it also increases the cost of telemedicine in the home.

Telemedicine is a relatively new technology that both intimidates and fascinates our patients. Once when we set up a patient station in a home, family members gathered around the camera to watch the video visit. One elderly patient remarked, "It's just like when the first television set arrived in my neighborhood." We need to take advantage of this type of attitude toward telemedicine while diminishing negative reactions to it. Acceptance of telemedicine in the home will not happen overnight and will take a concerted educational program to promote it.

### Clinician acceptance:

Clinician acceptance of novel treatment strategies is traditionally slow, especially if it impacts negatively on remuneration and is accompanied by extensive government regulation with attendant loss of autonomy. Most third-party insurers, especially Medicare, do not reimburse clinicians or hospitals for home telemedicine except to rural areas, such as the outer Hawaiian Islands. Because of this, the development of telemedicine has been retarded largely for economic reasons. Nonetheless, there are many reports of successful cost-savings and increased productivity from telemedicine trials.<sup>3,4</sup>

There is still considerable skepticism amongst clinicians about changing the current practice of watching patients in the hospital until they are completely stable.<sup>14</sup> This reaction may be based on traditional teachings, as well as clinicians' fear of an unsuccessful outcome and the potential threat of litigation. Medical-legal challenges for bad outcomes from telemedicine in the home will undoubtedly occur. However, with additional outcomes data confirming our preliminary results, telemedicine in the home will be advanced to the level of a standard of care.

### Conclusion

Telemedicine in the home has several advantages over hospitalization. It promotes more efficient utilization of hospital beds resulting in cost savings. Our results would indicate that it promotes more rapid convalescence than hospitalization. How it does this is not known, although it may relate to several factors, one of which is the removal of patients from a passive, dependent posture in the hospital to being a more active participant in their own medical care at home. This may promote in patients a sense of empowerment over their illness. Whatever the reason, outcomes such as this will hasten the acceptance of telemedicine by patients, care-providers, clinicians, and insurers.

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