An Innovation in Healthcare Delivery: Hospital at Home

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A healthcare delivery system which partially substitutes for inpatient hospital care – hospital at home – is becoming widespread worldwide, but has only recently gained a foothold in the United States. An overview of this system is presented along with results of outcomes research associated with it. The technologies driving this system are discussed, and a rationale for its more widespread adoption in the U.S. is made.

INTRODUCTION

In some countries, demand for hospital beds exceeds the supply, a situation which is expected to become more widespread as the population ages (Foubister, 2011). Although the U.S. did have excess hospital beds in the past (e.g., see Bazzoli, et al., 2006), this no longer appears to be the case (Evans, 2012; NJDH, 2008; Queram, 2012), with some researchers predicting the need for an 18-28% increase in the number of U.S. hospital beds (Shactman, et al., 2003). One approach to effectively increase the number of available hospital beds is to decrease the time for which patients are admitted to the hospital. Making this approach difficult is the fact that patients may still require hospital-level care.

One of the fastest-growing alternatives to what has traditionally been referred to as "inpatient" medical care is the provision of hospital-level care to patients in their homes (Jacobs, 2001; Papazissis, 2004; Shepperd, 2009). The most prevalent form of acute home medical care is "hospital at home" (HaH), the provision of medical services normally associated with acute inpatient hospital care, but provided instead in a patient's home (Leff, 2009). Although criteria vary, HaH involve the provision of care in the patient's home which:

(1) eliminates or reduces an inpatient hospital stay;
(2) is similar to care normally provided in a hospital;
(3) is clinically appropriate; and
(4) is not provided by usual community-based services (Lemelin, et al., 2007).

HaH models have been accepted in many countries around the world, particularly in the United Kingdom, Europe, and the Middle East (Kane, 2007). In some countries, the HaH model even predominates; e.g., nearly all the hospitals in Victoria, Australia have HaH programs (Montalto, 2010) and in Canada, the Ontario Ministry of Health and Long Term Care has recommended that HaH be launched throughout the entire province (Sinha, 2012). Currently only a few such programs exist in the U.S. (Graham, 2012a; Senior, 2012), but the number seems to be growing, with successful HaH programs established at, for example, Johns Hopkins Bayville Medical Center in Baltimore, MD (Carter, 2012), Presbyterian Healthcare Services in Albuquerque, NM (Kuehn, 2012; McCain, 2012), Mercy Health, a

not-for-profit health system in Cincinnati, Ohio (Landro, 2013), and several VA hospitals (Graham, 2012a).

Literature reviews and meta-analyses have categorized HaH programs as either admission avoidance or early discharge (Shepperd, 2009). Admission avoidance HaH programs are designed to avoid hospital admission altogether (e.g., by treating infectious diseases and thromboembolic disorders). Early discharge HaH programs discharge the patient from the hospital directly to home to receive medical care that would be traditionally have been delivered in hospital following an initial surgical or acute medical treatment delivered in hospital.

In the United States, it would seem that managed care would embrace either or both of these models of HaH, if only for financial reasons. Admission avoidance HaH programs would certainly be profitable for managed care organizations (MCOs), as they eliminate hospital stays, and hospitals are the most costly venue where patients can receive care. Early discharge HaH programs would also be financially advantageous for MCOs because by definition they decrease the number of costly hospital days incurred by patients. MCOs must understand, however, that these cost savings are achieved only if the care provided by HaH programs is appropriate. For example, Medicare now will withhold payment for patients re-admitted to the hospital sooner than predicted, at least those having certain conditions (Landro, 2013).

Patients treated in admission avoidance HaH generally have these characteristics (Leff, et al., 1997):

(1) the condition occurs with some frequency and accounts for a significant number of hospitalizations;
(2) the diagnosis is relatively uncomplicated and can therefore be made rapidly without substantial consultation or invasive testing; and
(3) the treatment is well defined and can be delivered in a feasible, safe, and efficient manner at home.

The early discharge group includes chronically ill patients diagnosed with multiple illnesses and needing acute episodic care. The majority of these patients are elderly and disabled, although pediatric patients with chronic illnesses may also be recipients of ongoing acute episodic care from HaH services. These patients often have difficulties with mobility and other activities of daily living, and have difficulty in maintaining their households. Many have care givers who provide assistance, and patients' use of existing community services is common. This group includes people of varying ages who, following an acute event, require short-term, intensive medical treatment such as intravenous antibiotics, intensive rehabilitation or post-surgical care, but do not need long-term nursing and maintenance care (Siu, et al., 2009). Another component of this early discharge HaH group includes patients who may have less common diagnoses that are usually treated by sub-specialty inpatient units (Shepperd, et al., 2009b).

Another classification system for HaH is based on whether services are delivered predominately by specialists or subspecialists. Although this approach is sometimes useful for understanding the differences in case mix between these types of HaH programs, significant crossover exists between specialist and subspecialist HaH programs, as some types of clinical care may be provided by specialists in one HaH setting and by sub-specialists in another. The majority of HaH programs are the specialist type, providing care across a range of common conditions. In the specialist approach, a different group of staff usually provide in-home care compared with staff providing acute hospital care. In the sub-specialist model, care is provided by a more narrow clinical team having knowledge and skills relating to a specific condition, with the same doctors, nurses and allied health professionals usually involved in providing care in both hospital and at-home settings (Shepperd, 2005). Subspecialty HaH care usually requires a sufficient caseload of patients being available for the HaH service to be feasible and efficient (Chevillotte, 2008).

BASIS OF CARE

Substantial variation exists between HaH programs with regard to the illnesses treated, the acuity of patients involved, the source of admission, the composition of the treatment teams, whether the patient was at one time considered to be an inpatient before being treated in HaH, and the amount of physician

and nursing care coverage provided. HaH requires substantial medical technology in provision of care, and also requires special understanding of how pharmaceuticals are used at home.

The most common conditions and treatments delivered by HaH include treatment of infections, particularly genitourinary tract, respiratory tract, skin, joint and soft tissue infections; anticoagulant therapy; post-surgical acute care; congestive heart failure treatment; treatment of chronic obstructive pulmonary disease (COPD); and rehabilitation services (Shepperd, 2009**)**.

Eligibility criteria for access to HaH services reflect the differences between patient groups. HaH programs are appropriate only for patients with a definitive diagnosis, as outlined in the eligibility criteria set by each service. For example, to be enrolled in the HAH program at Presbyterian Healthcare Services in Albuquerque, NM, patients must meet the following criteria (Foubister, 2011):

(1) be diagnosed with chronic heart failure, chronic obstructive pulmonary disease, community-acquired pneumonia, cellulitis, complex urinary tract infection, dehydration, nausea and vomiting, deep vein thrombosis, or stable pulmonary embolism;
(2) be sick enough to require hospitalization but not so sick as to be admitted to the hospital's intensive care unit;
(3) live close enough to the three participating Albuquerque hospitals to be able to return to one of the hospital's emergency department within 30 minutes, if needed;
(4) be covered by Presbyterian Health Plan or chooses to pay for the Hospital at Home service, as the program is not covered by other payers.

Depending on the hospital, criteria may encompass not only the health care needs of patient groups, but may also reflect patient characteristics, patterns of care, case-mix, and staff composition (Leff and Montalto, 2004). The majority of programs operate as hospital outreach programs, although they may also be operated by community health services, or hospital-based teams working in conjunction with community-based services (Shepperd, et al., 2009).

Staffing

The composition of staff providing HaH services differs among countries, service providers, and HaH models. Nurses are often responsible for the majority of care, causing some to believe that HAH is simply home health care under a new name (Maguire, 2012). However, the nurses associated with many HAH programs are specialist and/or HaH-dedicated nurses (Askim, et al., 2004; Caplan, et al., 2006; Harris, et al., 2005). The most commonly provided allied health services are physiotherapy and occupational therapy (Sheppherd, et al. (2009b).

The physician's role in HaH varies widely. Early discharge models generally involve physician supervision from a distance, while admission avoidance models report varied doctor roles. In some models, community-based general practitioners are available for home visits to patients. In other models, doctors make rounds at the patient's home every day based upon the premise that HaH patients require the same care that they would have received inside the hospital (Cheng, Montalto, and Leff, 2009). The appropriate clinical skills and competencies required to deliver HaH are dependent on the service delivery model of the program and the range of clinical duties associated with provision of care. The medical skills for delivering HaH care are found across clinical specialties.

General practice, emergency medicine, geriatrics and general hospital medicine in particular are clinical areas with direct relevance to HaH. However, in addition to these skills areas, the ability to adapt a clinical unit model to a patient's home is required. This aspect of HaH care is novel and therefore suggests that HaH may be an emerging clinical specialty in its own right. The need for further development of the "specialty" has been recognized (Montalto, 2002), but there appears to be no published literature regarding specialty training for HaH, or the existence of separate colleges (or faculties within colleges) to support continuing professional development of medical practitioners in this field.

The nursing skills for delivering HaH care are drawn from a range of specialty areas. The benefits of nursing specialization in HaH have been acknowledged, however formal development of the nursing specialty of HaH across countries has been variable (Duke and Street, 2003).

Referrals

By definition, HaH units depend upon referrals to obtain patients, normally from medical practitioners who make key decisions regarding care requirements. Many programs spend significant time and effort in generating these referrals, employing staff to identify patients, providing information sessions and written material for staff, and using personal contacts to increase and maintain referrals. In most admission avoidance HaH programs, patient referral is from a hospital's Emergency Department, but patients are also referred from medical practitioners in the community. Early discharge HaH referrals are predominantly from inpatient situations (Shepperd, 2009).

SERVICE PROFILES AND OUTCOMES

Post-surgical

Post-surgical care has been studied within HaH service delivery models for a range of surgical conditions. Much post-surgical care has been demonstrated to be safe and effective, with a strong patient preference for receipt of services at home (Moeller, 2012).

Orthopedic surgery in particular is an area of extensive study of HaH models of post-surgical care. Studies have demonstrated both clinical and financial advantages to orthopedic after-care in home settings, provided that post-operative pain can be adequately controlled (Russon, et al., 2009; Stevens, et al., 2004). Models are predominantly led by nurses, but often also involve allied health practitioners. Patients are admitted to HaH service for orthopedic post-operative care through early hospital discharge with generally low readmission rates. In one study, mean length of hospital stay post hip or knee replacement was reduced by over 42% for total hip replacement and by 33% by provision of post-operative care at home. Complication rates were equivalent and there were no statistically significant differences in clinical outcomes between inpatient and HaH. Patients in this study rated HaH care highly (Russon, et al., 2009).

There is also evidence that delivery of post-operative HaH care following other types of surgery - including surgery for hernia and varicose veins (Adler, et al., 1977; Ruckley, et al., 1978), coronary artery bypass grafting (Booth, et al., 2004), and cataract surgery (Willins, Grant and Kearns, 1999) - is safe and effective.

Internal Medicine

Numerous examples exist in the literature where subspecialty HaH models have been used to provide medical services successfully to patients. Some of the more common subspecialty models described are for the treatment of diabetes, respiratory failure and complex chronic illnesses. Looking at diabetes treatment in the home, HaH units can effectively commence insulin for patients with type 1 and type 2 diabetes (Monalto, et al., 2001). Subspecialty HaH services, usually provided by endocrinologists and diabetes educators, can manage 43% of newly diagnosed children wholly at home, and reduce the number and duration of hospital admissions without deterioration in blood glucose control (McEvilly and Kirk (2005). Diabetic infections normally treated in inpatient settings are also able to be successfully treated using a HaH model of care (Esposito, et al., 2008).

HAH services have also been demonstrated to be safe and effective for service delivery across a range of other general internal medicine conditions including:

(1) provision of parenteral nutrition, blood transfusion, and for percutaneous endoscopic gastrostomy management in health systems where these services are usually provided in acute in-patient settings (Dollard and Dunn, 2004);
(2) the management of acute and chronic pediatric respiratory, gastro-intestinal and infectious diseases (Bagust, et al., 2002; Sartain, et al., 2002);
(3) complex wound care and ulcer management (Montalto, Portelli, and Collopy, 1999; Genoud and Weller, 2008); and
(4) provision of acute anticoagulation treatment, including for deep vein thrombosis (Smith, et al., 2002).

Home management of deep vein thrombosis with low molecular weight heparin has been shown to be safe and effective. Patients treated at home with low molecular weight heparin have a lower recurrence of venous thromboembolism, less major bleeding and fewer deaths than those managed as inpatients. Home-based care is also more cost-effective than inpatient care (Othieno, Affan, and Okpo, 2007). Patients with sub-massive pulmonary embolism (PE) can be treated as outpatients or in the home. Good outcomes have been demonstrated for outpatient treatment of patients with PE (Ong, et al., 2005).

HaH have been shown to be safe and effective for cardiac treatment and rehabilitation across a range of countries and for a number of cardiac conditions (Dalal, et al., 2010; Taylor, et al., 2007). Home-based intravenous diuretic and inotropic therapies can be safely and effectively delivered via HaH services to treat acute and severe decompensated heart failure. Patients can remain at home to receive appropriate medical care, reducing inpatient hospitalizations (Madigan, 2008; Ryder, et al., 2008). Home-based versus hospital-based cardiac rehabilitation after acute myocardial infarction (MI) achieves equivalent outcomes at up to 9 months post MI (Taylor, et al., 2007).

HaH programs have been applied quite successfully to the treatment of acute exacerbations of COPD, a major source of inpatient admissions for many hospitals world-wide (Davison, et al., 2006: Utens, et al., 2012). There is some evidence of reduced mortality rates (Jeppesen, et al., 2012) and reduced length of stay (Aimonino, 2008) for COPD treated via HaH instead of traditional inpatient hospitalization. No significant difference in hospital readmissions between patients treated in HaH and traditional inpatient care have been demonstrated. However, patients predominately prefer HaH to inpatient care (Graham, 2012c; Ram, et al., 2009).

TECHNOLOGICAL DRIVERS OF HaH

Extensive use of new and existing technology facilitates new approaches to the provision of care to patients and to promote information sharing among caregivers (Hernandez, et al. 2009). The use of technologies to support HaH is a subject of significant interest and importance, especially as a meta-analysis of five clinical trials including 844 patients demonstrated that the provision of hospital care at home and traditional hospitalization resulted in similar outcomes at lower cost for HaH (Shepperd, et al., 2009a).

Telemedicine is the use of technology to provide healthcare over a distance. Tele-homecare, a form of telemedicine based in the patient's home, is the use of communication and other technologies that enables the interaction of voice, video, and/or health-related data (Seigler, et al., 2007). Many HaH services worldwide have adopted tele-homecare to assist with the care of the growing population of chronically ill adults and children (Bowles and Baugh, 2007).

Potential benefits of telemedicine include:

(1) improved access to information (Skinner, Maley, and Norman, 2006);
(2) improved communication between/among health professionals (Clemensen and Larsen, 2007);
(3) the capacity to provide care in settings not previously possible (Zhang, He, and Wei, 2008; Coons and Carpenedo, 2007);
(4) home monitoring and treatment (Wilson, et al., 2000); and
(5) decreased health-care costs (Anonymous, 2007).

Information for Patients and the General Population

Electronically stored information is often accessed by patients through the Internet. The Internet provides patients with information about health and disease, thus providing opportunities which can assist patients in their better understanding the nature of their disease, its treatment and prognosis, as well as information regarding diagnostic investigations and the effect that various treatments might have (Skinner, Maley and Norman, 2006). In fact, 61% of Americans have accessed the Internet seeking health information (Fox and Jones, 2009). Patient knowledge and understanding regarding of their conditions is essential to improving patient self-management. Provision of information via telemedicine is an effective

strategy for delivery of health education to people from culturally and linguistically diverse backgrounds and for a range of chronic conditions (Gottlieb and Blum, 2006).

Improved Communication between Health Professionals

Communication between health care providers, particularly between community and hospital-based providers, has traditionally been paper-based. Newer technologies are increasingly available to enable patient health records to be more accessible to both providers and patients, and to enable sharing of electronic information among providers. Electronic health records (EHRs) can avoid duplication of expensive and unnecessary investigations, improve clinical decision making, and reduce the time associated with preparation, dissemination, and reading of paper-based communication between providers (Zhang, He, and Wei, 2008).

Provision of Care Not Previously Deliverable

Telemedicine has been shown to enhance service delivery in small, rural communities as an alternative to travel, and to address local deficiencies in specialist care. Mistiaen and Poot (2006) have discussed how advances in communications technology have increased the range of methods and speed by which health-care professionals and patients can communicate, providing faster access to specialist clinical support, convenience, and time savings for patients, improved equity of access to care between and within regions, especially where specialized services are centralized in urban centers.

Telemedicine has also been demonstrated to improve verbal interactions in dermatology, ophthalmology and wound care; i.e. via videoconferencing for diagnosis and treatment (AHQR, 2006). Home-based telemedicine interventions in chronic diseases enhance communication between patients and providers and facilitates closer monitoring of overall health when conducted in settings with specialized equipment and dedicated staff (Artinian, et al., 2007; Green, et al., 2008).

Enhanced video-conferencing networks within health services, desktop video-conferencing using products such as Skype® and WebEx®, and the use of electronic professional networking (e.g. Sharepoint®, Wikis, web logs [Blogs] and chat rooms) may be useful to enhance communication between health professionals, to develop evidence-based policies, protocols and guidelines within organizations, for the remote attendance of the health professional at case conferences, multidisciplinary team meetings, treatment planning sessions and to facilitate electronic consultations between patients and health care providers, often reducing the need for transport and/or accommodation for the patient (Chen, et al., 2006).

Clinical communication has also successfully been enhanced by the use of Email. A trial of email communication between patient and/or care giver and a specialist burn team investigated whether patients could capture suitable clinical images with a digital camera and add the necessary text information to enable a burn team to provide appropriate follow-up care. Participants did not require intensive training or support, low-resolution images were deemed sufficient for clinical diagnosis, and clinical information was generally accurate enough to enable appropriate diagnoses to be made (Johansen, et al., 2004).

The systematic application of technologies such as these to HaH service delivery could address some of the professional isolation and supervision concerns regarding staffing of HaH services. However, before this occurs, rigorous pilot testing and evaluation of these technologies in the HaH setting will be required.

Home Monitoring and Treatment

The miniaturization and simplification of other technologies formerly available only in a hospital also facilitate HaH. Recent advances in home intravenous infusion technologies allow infusions to be delivered in a highly controlled manner with programmable pumps, also known as “smart pumps,” which have dose-checking capability, predefined dose limits, bolus delivery options, and the ability to recognize programming errors before medication delivery. Pumps have evolved from large stationary units to tiny portable devices that can even be carried on a belt clip (Wilson and Sullivan, 2004). Ventilator technology has become increasingly portable with some being the size of laptop computers, weighing as little as 5 kilograms (Lewarski and Gay, 2007). Oxygen therapy has evolved from reliance on large bulky

cylinders to safer, more compact, lightweight oxygen concentrators, devices providing oxygen therapy to a patients at minimally to substantially higher concentrations than available in ambient air. Most concentrators can run on either DC or AC current (Gallegos and Shigeoka, 2006). Advances in radiology also enable provision of home-based diagnostic services. Simple home-based x-rays are now available and are comparable in quality to traditional hospital x-rays (Bankhead, 2011). Handheld ultrasound devices have been developed, which enable investigations such as echocardiograms and diagnosis of deep vein thrombosis or pleural, peritoneal, or pericardial fluid in HaH (Galasko, Lahiri, and Senior, 2003; Lapostolle, et al., 2006)

Continuous monitoring of patients in certain diagnostic categories, outside hospital environments, has been the subject of a number of studies. Some researchers have found little or no differences in outcomes between HaH and traditional hospitalization (Ho, et al., 2007; Malasanos, 2006; Shepperd, et al., 2008). The application of technologies to the home monitoring and treatment of patients with a wide range of diseases could be applied to the delivery of HaH services, and may improve the quality, safety and efficiency of services. Families rated such services highly and valued the early reunification of the family at home through the use of the technology (Young, et al., 2006). Patient satisfaction has also been shown to be higher with HaH (Shepperd, et al., 2009b), and stress on family members to be lower (Leff, et al., 2008).

Improved care and reduced health services costs associated with delivering care for heart failure via specialist nurse-led telephone calls have been demonstrated. Hospital readmissions, cumulative readmission costs, and length of stay were reduced for patient treated via HaH services (Benatar, et al., 2003). Home-monitoring for heart failure is technologically advanced. It includes the use of peripheral devices for measuring and automatically transmitting electrocardiograms (EKGs), blood pressure, heart rate, medication use, bodyweight and symptoms (Oeff, 2010). Patients whose heart failure was once thought to be too complex to be managed outside the hospital are now being treated via HaH: 75 pounds of fluid were drained from one heart failure patient in a HaH program in 3 weeks (Maguire, 2012).

Clinical trials of specialist nurse-led telephone-based care for provision of HaH care for patients with acute exacerbations of COPD have also been done. HaH patients demonstrated better knowledge of their disease, better self-management and higher patient satisfaction where achieved using this method to augment face-to-face service delivery (Hernandez, et al., 2003).

Home monitoring has been demonstrated to improve the mental and physical needs of the elderly and chronically ill, and assist them to remain out of hospitals and other institutions. This can improve their quality of life, as well as reduce the costs of prolonged stays in hospital care facilities (Gottlieb and Blum, 2006). Home monitoring systems to monitor physiological variables, such as EKGs and blood pressure (Bratan, Jones and Clarke, 2004; Frantz, 2003; Guillén, et al., 2002), and video-links (Autio, et al., 2007) that allow health professionals and relatives to interact more frequently with the elderly are now available.

Trials of the suitability of Internet-based video-phones for use in the homes of families in need of pediatric palliative care services have been undertaken. The technology is a feasible alternative to face-to-face service provision, but during the trial several technical problems were encountered, potentially affecting the reliability of the approach (Bensink, et al., 2004). A videophone system was used to link cancer patients undergoing chemotherapy in HaH with care providers in the healthcare facility. An important outcome was an improvement in quality of life due to use of the videophone service (Laila, et al., 2008).

Home dialysis is available for patients with chronic renal failure who are able to self-care, however, there are few reports on the use of telemedicine in dialysis treatment in general, and in home dialysis specifically (Rygh, et al., 2012). This is likely at least partially because the U. S. Centers for Medicare and Medicaid in 2007 re-affirmed its position that dialysis centers were not approved sites for telemedicine (Whitten and Buis, 2008). Whitten and Buis (2008) have demonstrated that patient's confidence and ability to home dialyze can be improved through the use of video-links to supervise the dialysis procedures. Dialysis centers can use telemedicine to monitor patients, observe technique periodically, and provide care to patients in case of complications.

Telemedicine and associated technology (telephone, video and internet) have been shown to improve the delivery of HaH care for ulcers (Clemensen and Larsen, 2007) and chronic wounds (Dobke, et al., 2008). They have also been successfully used to monitor patients acutely ill with infections, such as community-acquired pneumonia, skin and soft tissue infections, and urinary tract infections, resulting in better satisfactory outcomes, cost savings and more rapid convalescence of the patient (Eron, et al., 2004a, b; Chambers, et al., 2002).

Several types of specialty care, including dermatology, ophthalmology, wound care, and treatment of infections, have been studied in small clinical trials and appear to allow accurate diagnosis and management through both real-time interactions and "store-and-forward" applications, in which clinical data, including video images, are collected and stored for later review by a clinician (Moreno-Ramirez , et al., 2007).

A systematic review of 40 articles was conducted evaluating telehealth technology where peripheral medical devices were used to deliver home care for adult patients with chronic illnesses. Patients and providers were accepting of the technology and it appears to have positive effects on chronic illness outcomes such as self-management, re-hospitalisations, and length of stay (Bowles and Baugh, 2007).

Significant questions exist about where telemedicine should be used and whether or not its use is supported by high-quality evidence (Hersch, et al., 2007). Early studies (e.g., Hailey, Ohinmaa and Roine 2004; Hersch, et al., 2001) questioned the quality of both study design and sample size. A recent systematic review of 65 studies of home telemonitoring for 4 chronic diseases (pulmonary conditions, diabetes, hypertension, and cardiovascular diseases) suggests that while telemonitoring is a promising patient management approach, further studies are needed to examine its clinical effects and cost effectiveness (Paré, Jaana and Sicotte, 2007). However, since only a single study since 2008 (Bolton, et al., 2011) was found to express concerns regarding the quality of evidence on which conclusions about telemedicine are based, the debate about evidence quality of studies of telemedicine seem to have been largely resolved.

Reduced Health-Care Costs

Tele-homecare can contribute to a reduction in healthcare costs (Butcher 2012; Klein, 2011; Shepperd, et al., 2009a). However, to date cost evaluations have predominately involved limited numbers of patients with varying kinds of tele-homecare interventions for a limited number and variety of few chronic illnesses. Further research is indicated to clarify how the best indications for tele-homecare and how its benefits can best be maximized (Bowles and Baugh, 2007).

HaH had been shown to provide significant cost savings over traditional in-patient hospitalization, given the right circumstances. A Swedish study of HaH services provided to infants and children with stable acute illness using mobile video-link units found HaH to be 30% cheaper than conventional hospital care with higher and patient satisfaction. At the conclusion of the Swedish study the program was deemed to be so successful that it became a permanent part of children's care provided at the Karolinska Hospital (Bergius, et al., 2001). More recently, a study of telemedicine in India found that costs of dialysis treatment there could be decreased 90% if telemedicine was employed instead of traditional hemodialysis (Govindarajan, 2012).

The success of the HaH program at Alburquerque, NM-based Presbyterian Healthcare Services has recently been documented, in both the academic literature (Carter, 2012; Cryer, et al., 2013; Foubister, 2011; Kuehn, 2012) and lay press (Graham, 2012c; Landro, 2013). In addition to a 19% cost savings achieved, HaH patients demonstrated comparable or in some cases better, outcomes as similar inpatients and this was in addition to higher patient satisfaction levels. The study found no statistically significant difference in 30-day readmission rates between the two groups. Ninety three percent of patients eligible to do so chose to receive care through the HaH program.

FUTURE CONSIDERATIONS

What does the future hold for technology and HaH? It's extremely difficult to predict technological advances and their potential applications, but some possibilities seem likely. The trend toward increased miniaturization should certainly be expected to continue and the results should continue to affect the development of HaH. Nanotechnology has existed in healthcare for years (Feder, 2004), but is still being touted as a potential major platform for healthcare technology development (Prasad, 2012). In fact, despite the catastrophic consequences of the 2008-2009 meltdown of capital markets, the global market for nanomedicine is expected to grow from $63.8 billion in 2006 to $130.9 billion in 2016, a compound annual growth rate of 12.5% (BCC Research, 2012). On a somewhat more macro scale, but still looking at technology's size decreasing, an electrical engineering research group at Washington State University – Pullman envisions "a lightweight, simple package caregivers can purchase from Home Depot or Lowe's" that could be used to conduct hospital-level monitoring at home (Otto, 2011, no page). Tablet computers, which are easy to use and completely portable, will help with both technology adoption and use of EHRs (Sandomirsky, 2012), and the trend of decreasing size of computers will almost certainly continue, perhaps eventually even reaching the quantum molecular level (Lambert, nd).

Healthcare data storage "in the cloud" looks promising, especially for larger healthcare organizations (Sharpe, 2012), although certainly hurdles to its adoption do exist. Data storage "in the cloud" would allow institutions to pay for only what they actually use, instead of having to purchase expensive and potentially quickly obsolete systems; it would also make the sharing of EHRs much more feasible (Danios, 2011). However, significant legal hurdles in some countries (e.g., requirements associated with the Health Insurance Portability and Accountability Act [HIPAA] of 1996 in the U.S.) would have to be overcome (Denzell, 2012). Regardless of the legal issues involved, improved data storage and access should help HaH (and other health care institutions) improve patient care as co-ordination of that care becomes more and more important.

An important and growing trend is the use of electronic communication technology for patients. Mobile technology allows patients to access healthcare information easily on the Internet, while mobile applications ("apps") allow the monitoring of personal health conditions such as diabetes via smartphones (Nayyar, 2011). Although few such healthcare apps yet exist, their development is expected to accelerate in the future (Singer, 2011).

CONCLUSIONS

Internationally, one of the fastest-growing approaches to what has been known for years as "inpatient" care is the provision of acute care to patients in their homes. Acute home care medical models have been accepted in many countries around the world, and their acceptance U.S. is limited, but growing. The increasing pressure in the U.S. to lower health care costs and improve the quality of medical care could lead to the widespread acceptance of such programs in the U. S. as the model become better understood, provided that an appropriate reimbursement system can be developed.

That technology has been and will continue to be an important driver of developments in healthcare generally and HaH in particularly seems indisputable. Will HaH be a panacea which "cures" the problem of consistent increases in the percentage healthcare costs represent in U.S. GDP? Certainly not! Is the more widespread adoption of the HaH model something which can affect the magnitude of the increase in costs attributable to hospitals in the U.S.? Almost certainly yes! Under the condition that the HaH model is limited to patients whose medical conditions are such that appropriate care can be delivered safely, effectively, and at less costs than traditional in-patient care, the more widespread adoption of this model of care delivery in the U.S. is indicated.

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