Home Telehealth: Connecting Care Within the Community

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Home dialysis

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Introduction

Renal failure is a global issue. More than one million patients with end-stage renal disease (ESRD) receive dialysis treatment worldwide.[1] On a per-capita basis, dialysis is among the most costly of the chronic diseases, with costs of up to €60 000 a year.[2] In 2005, the global market for dialysis services, including clinics, treatments and renal care products, was estimated to be $48 billion.[3]

When the kidneys fail, toxic products build up in the blood. This waste must be removed by artificial means – typically through haemodialysis or peritoneal dialysis (PD). PD is usually undertaken at home, but an exchange of fluid can also be performed at work or during travel. With haemodialysis, patients have to be connected to a dialysis machine – usually located in a hospital or clinic – at least three times a week. The patient's quality of life generally is better with PD than with standard haemodialysis.

Telemedicine and hospital dialysis

Telemedicine has been used successfully to support haemodialysis in small hospitals and clinics. Most physician–patient interactions do not require palpation and therefore are possible by videoconferencing. Some major dialysis centres – such as in the US (Washington DC and Texas) and Australia (Adelaide) – have supported patients undergoing dialysis at satellite units using telemedicine.[4–6] The technique seems to be successful in avoiding unnecessary travel in those satellite centres in which it is used. Indeed, it seems surprising that telemedicine is not used more widely in hospital dialysis to reduce patient and staff travel.

Given the success of teledialysis for patients in small hospitals and clinics, a natural development is to try and support patients being dialysed at home. Encouraging reports exist about the benefits of renal telemedicine to the home from rural areas of countries like Australia, the US and elsewhere.[7,8] The benefits include savings in journeys, time and related financial costs by medical professionals and patients; avoidance of inpatient services; and a sense of increased support and security for patients.

Telemedicine opportunities in home dialysis

In most countries, the percentage of patients who receive haemodialysis at home is very low or negligible, with the exceptions of New Zealand (14%), Australia (10%) and France (5%).[1] PD, which is usually performed at home, also shows wide variations between the countries for which data are available: from 45% of all patients in New Zealand and 19% in Canada, to only 5% in Germany and 4% in Japan.

Home dialysis supported by telemonitoring seems likely to become a major application of home telehealth for three main reasons:

- Home dialysis can produce improved medical perspectives for patients.[9] In addition, more flexibility allows patients better adaptation to a changing work environment and to various leisure activities, which in turn translates into a higher quality of life.
- Although home telemonitoring is still at an early stage of development,[10] the most promising applications are in fields such as chronic illnesses, where it can be used to reduce the number of complications, reduce costly hospital stays and respond to new needs in home care for an aging population. The same advantages can be expected to apply to ESRD.
- Various empirical reports in the literature suggest that home application of both haemodialysis and PD leads to a considerable reduction in overall treatment costs.[11]

Home telemonitoring

Research on home telemonitoring of patients on dialysis – both for haemodialysis[12] and PD[13] – suggests considerable potential to improve the quality of life for some patients with ESRD. A prerequisite is an adequate system approach to the clinically and technically complex situation of haemodialysis, and clear criteria for identifying and selecting patients who may benefit most from home dialysis supported by telemonitoring. Integrating telemonitoring with nightly automated peritoneal dialysis (APD) treatment for difficult paediatric patients has been shown to be useful in detecting and solving the clinical and technical problems associated with this form of treatment.[14]

Nocturnal home haemodialysis with telemonitoring has been piloted by the McGill University Health Centre, Montreal. Patients underwent a 4–6-week training session, during which they were taught to operate the dialysis equipment, properly connect and disconnect themselves, and troubleshoot alarms. They also had to undergo a home evaluation to ensure that requirements for storage, quality of electrical power supply, and water and drainage were met. The dialysis machines were linked via the Internet to a monitoring centre, where trained personnel were available throughout the night to deal with problems.[15]

A similar application has been tested at the Toronto General Hospital. A completely automated system monitors dialysis machines and patients' vital signs. Data from physiological sensors are transmitted wirelessly to a computer in the home, which is connected via a high-speed Internet connection to central servers. If any problems occur with patients or equipment, the system automatically alerts the appropriate caregiver or technician by email or pager.[16]

Automated telemonitoring is designed to give patients the confidence they need to conduct dialysis on their own. Home-based nocturnal haemodialysis is more effective than conventional, clinic-based dialysis, for which patients must travel to a hospital or clinic three times a week. Home nocturnal dialysis enables patients to dialyse at night for 40 hours a week as opposed to the 12 hours a week that is standard practice with conventional haemodialysis.[17] An additional advantage of home dialysis is that patients can spend more time at work and with their family.

European dialysis telemonitoring project

The aim of a recent European project was to develop and test a modular telehealth home-care system for chronically ill people.[18] The aim was to improve outcomes for patients with various chronic diseases, such as heart failure.[19] Here we describe the application for supporting ESRD and its results.

Requirements analysis

A small study of user requirements (from the physicians' point of view) was conducted. The survey concerned whether telehealth applications could be expected to improve the treatment of patients with ESRD. We developed a well-structured questionnaire to guide discussions with 15 nephrologists – specialists in private practice as well as in teaching/university hospitals. The small sample means that the data reported should be regarded as indicative in nature. The specialists believed that home monitoring would probably most benefit patients with comorbidities, specifically hypertension, who were undergoing home haemodialysis or PD (other co-morbidities mentioned were cardiac arrhythmia and coronary artery disease). Neither the age nor the home environment of patients was regarded as an important criterion (Table 14.1).

Table 14.1. Groups of patients who might benefit most from monitoring of vital data at home

Type of patient	Approving answers (%)*
Home haemodialysis	85
Home peritoneal dialysis	70
Comorbidities	
Hypertension	85
Diabetes	45
Living alone	30
Older patients: >70 years	30
Pre-dialysis with hypertension	60

*A total of 21 nephrologists (11 in hospitals, nine with private dialysis clinics and one in a foundation) were approached, of whom 15 participated in the survey. Not all responded to all questions.

Table 14.2. Priorities for improving healthcare through telematics by points (maximum of 100) and rank

Telematics components or systems	Points	Rank
Automatic transmission of data on vital signs from patients' homes to the office computer for patients with:		
• chronic renal failure or pre-dialysis	14	3
• home haemodialysis	28	1
• home peritoneal dialysis	28	1
Electronic information on patient's compliance with medication regimen	6	6
Improved communications with patients via:		
• Internet/email	11	4
• videotelephony	4	7
Improved training and education of patients through special Internet/World Wide Web services	9	5
Others	–	–

Experts were asked to identify the telematic applications they thought would best improve medical services to patients. They were asked to distribute a maximum of 100 points on the items shown in Table 14.2. Home monitoring of data on vital signs from patients on dialysis – whether treated by haemodialysis or PD – received the most points, followed by home monitoring in pre-dialysis patients. PD was the only item in the list that received points from all physicians interviewed.

Pilot trial

On the basis of these results, we conducted a pilot trial of home monitoring of patients on PD. Comprehensive material was prepared to inform patients and obtain their written consent. In parallel, we selected about 25 patients who used continuous ambulatory peritoneal dialysis (CAPD) on the basis of criteria identified through our survey. With CAPD, the patient empties a fresh bag of dialysate into his or her abdominal cavity via a catheter implanted into the abdomen. After 4–6 hours of dwell time, the patient returns the dialysate-containing wastes to the bag. The patient then repeats the cycle with a fresh bag of dialysate. This method does not require a machine, as the process uses gravity to fill and empty the abdominal cavity.

From the 25 patients on CAPD, seven patients with hypertension and one with hypotension were selected for inclusion in the trial in order of medical priority. These patients also had other diseases, including diabetes mellitus type 2, congestive heart failure, coronary heart disease and left ventricular hypertrophy. All eight consented to the trial. During the early phase, two patients were lost to the study: one changed to haemodialysis and another died. One new patient joined the trial, so we were able to collect data on seven patients in total. The staff was trained in handling the software before the equipment was installed in the patients' homes. Fifteen minutes of training was given to patients; this was found to be sufficient, with even older patients quickly gaining confidence in handling the equipment. The system architecture is shown in Fig. 14.1.

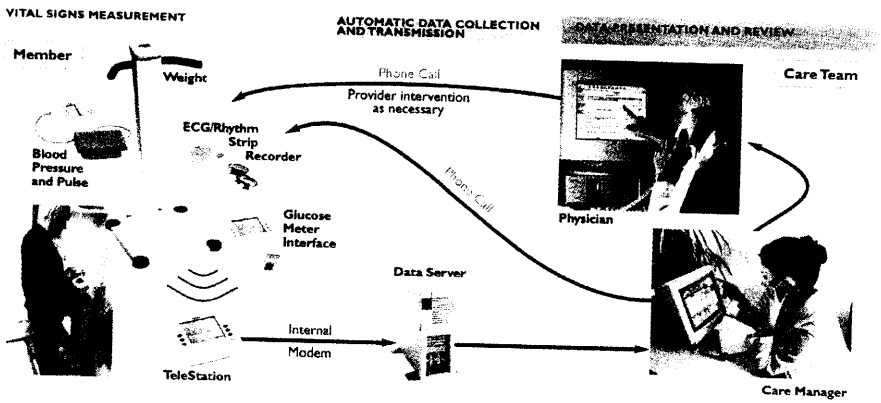


Fig. 14.1. System architecture of the Trans-European Network initiative Home-Care Management System (TENHMS) interactive telemonitoring service

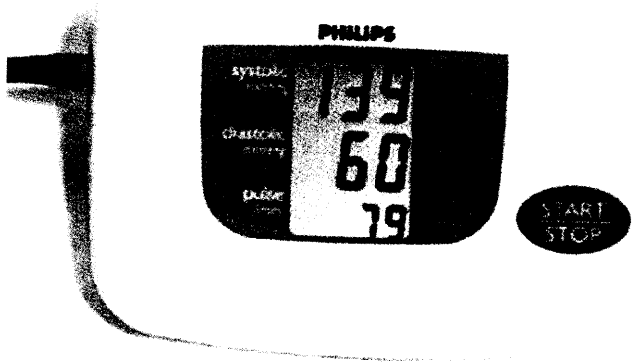


Fig. 14.2. Blood-pressure monitoring device

All patients measured blood pressure and pulse rate four times a day during each exchange of the dialysate (Fig. 14.2). In addition, on the morning before the first exchange, weight was measured (Fig. 14.3) and an electrocardiograph produced (one-lead rhythm strip; Fig. 14.4). One patient with heart failure was also asked to produce an electrocardiograph in the evening. All data were transmitted wirelessly from the measurement devices to a home hub connected to the patient's telephone line. Data were transmitted automatically to the central server at the nephrologist's office in the dialysis clinic. A printer attached to the server allowed printing of charts and reports for filing or for patients who requested their data.

Fig. 14.3. Body-weight monitoring scale

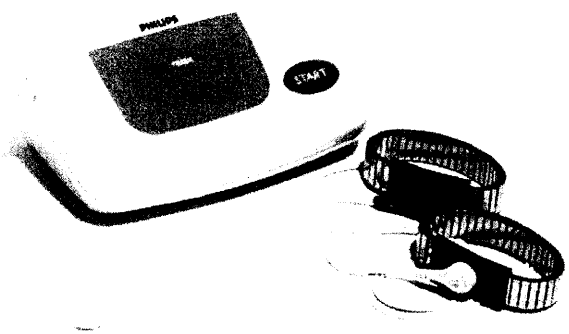


Fig. 14.4. Electrocardiographic monitoring device (one-lead rhythm strip)

General assessment by the nephrologist

The daily transmission of data allowed closer monitoring of patients and enabled more timely reaction to changes in their medical requirements. This became obvious in various instances involving patients whose health deteriorated over a very short time period. The physician was generally satisfied with the home monitoring system and devices. He also made specific suggestions for improving the clinical software, particularly with regard to the user interface.

Integration of the system into the routine processes of daily care did not pose any problems. The physician reported the impression that patients were feeling better looked after and cared for.

Clinical value

A system for differentiating between 'normal' patients on CAPD and 'risky' patients was devised.

- Normal patients – The 'normal' patient on PD has relatively stable physical health and may even go to work daily. They have been selected for treatment via PD, *inter alia*, because of their relatively stable situation. For such patients, the physician in the trial saw no specific medical value in daily home telemonitoring of vital data.
- Risky patients – Not unexpectedly, telemonitoring was particularly useful for patients with blood pressure and body weight concerns. For example, patients who had problems with their fluid balance – either because the filtration was too low or because they tended to drink too much – could be expected to have rapid weight fluctuations in a short time period. It is estimated that for about 10% of all present patients on PD, close telemonitoring would be indicated medically.

When the telemonitoring system becomes available for general introduction, it can be expected that the market potential for PD will expand considerably. Perhaps 10–20% of all new patients who would have required haemodialysis might qualify for treatment with PD. At present, their unstable health requires close monitoring, which requires them to visit the dialysis clinic three times a week. Patients on PD usually visit their physician only once a month or every six weeks.

Thus two types of patients benefited in the trial:

- those who needed only a certain time to determine and stabilize an optimum medication regimen
- those who continually caused considerable problems in establishing a stable medication regimen – that is, those who sometimes, even after only a short period of time, needed some readjustment.

On the basis of this positive initial assessment, four of the seven patients were chosen to continue the trial. Monitoring for two patients who assessed their own health as stable or did not see much benefit was discontinued. Another patient had to be admitted to hospital and could no longer participate.

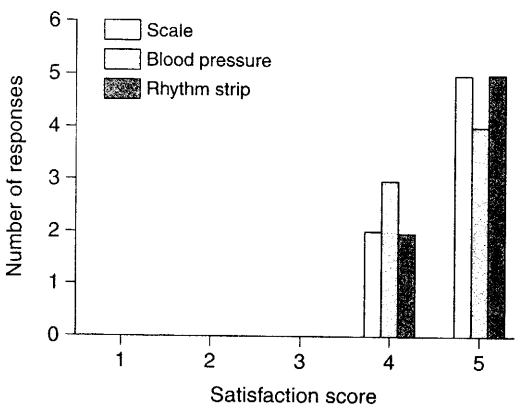
Assessment by patients

A four-page, easy-to-answer, written questionnaire survey and informal discussions showed that patients responded very positively to the trial, with all reporting high acceptance of the monitoring devices (Fig. 14.5). Three patients reporting on their perception of the system's effect on their health indicated the subjective feeling that they were much better cared for due to the daily monitoring (5 points on a scale from 1 to 5), two patients said that their care was considerably improved (4 points) and two noted 'only somewhat better care' (2 points). As people usually hesitate to vote for extreme values of 5 or 1 on a Likert scale, these results show that most patients had a high acceptance of the monitoring system and a positive assessment of its effect on their health.

In one case, the system supported attainment of longer-term, stable values, such that both the physician and patient saw no need for a continuation of daily monitoring. The study also showed that some patients will resist – or at least not value – telemonitoring.

Patients provided the following comments about the trial:

- 'I expected a better surveillance by my nephrologist – which indeed was the case.'
- 'I obtained much better control of my blood pressure. Before it was sometimes too high, sometimes too low.'
- 'I expected and received improved medical care by my doctor.'
- 'I hoped for an incentive to better monitor and keep track of my daily vital data and to establish my optimum dialysis parameters. I used to measure my blood pressure only once a month.'
- 'It helps me to not forget the daily measurements.'
- 'It provides me with a certain assurance, and it helps me to better control myself. Like when the blood pressure is too high, I take my drugs earlier, or when more fluid has accumulated or the weight has increased, I take a stronger dialysate.'



Technical assessment

In two cases, connection of the monitoring devices caused some problems because of incorrect wiring by the telecommunications provider or an old switchboard in one home. Once it was successfully installed, no significant technical failures of any part of the monitoring system occurred. The high reliability of the whole monitoring system, coupled with very efficient technical support, made it an ideal means of closely monitoring patients at risk, quickly adjusting their therapy in small steps as needed and balancing the medication regimen so that established boundary values were not exceeded.

Summary

The pilot trial showed that daily transmission of vital data – initially planned for six months only but extended for four patients by another six months – resulted in closer monitoring of certain patients on dialysis without interference with their daily routines. The daily collection of data enabled immediate reactions to significant changes in their health status, and adjustments to medication management were accomplished in a few days rather than as a follow-up to their regular 4–6-week visits to their physician. Telemonitoring also reduced patients' fear of performing inadequate dialysis. If additional data, such as temperature and fluid balance, could also be monitored closely, home telehealth could be applicable to an even wider patient population, such as other patient groups currently rated as too unstable.

Future telemonitoring in dialysis

Advances in technology, as well as expected changes in reimbursement systems, will provide important incentives and opportunities for home telehealth services in future. At the same time, they hold the potential to improve the quality of life for quite a few members of this growing patient population. New reimbursement schemes are expected to be implemented soon in Germany and other European countries. These will be based on diagnosis-related groups (DRGs) or, for the treatment of patients on dialysis, on fixed weekly or monthly sums, independent of the specific dialysis regimen. This will also have an effect on the ambulatory sector in general, which is still dominated by fee-for-service reimbursement. Such changes can be expected to provide new stimuli for expanding home dialysis by providing an economic incentive to reduce the costs per case.

Pierratos *et al* observed that, 'There is increasing evidence confirming that quotidian [daily] haemodialysis improves clinical outcomes in a cost-efficient manner. Provided that the reimbursement issues are resolved, these modalities may be used extensively at home as well as at the in-centre facilities. The revitalization of home haemodialysis will compensate for the decline in the use of continuous ambulatory peritoneal dialysis and the nursing shortage encountered in most countries.'[17]

In addition to the medical and direct cost benefits of home-based haemodialysis and PD, there will also be wider economic benefits. Because of the rigours of conventional

haemodialysis – with trips to clinics usually three times a week – most patients on haemodialysis do not work. Instead, they are on various forms of disability and income supports. Another option is the combination of home telemonitoring with visits to local/regional satellite centres connected via telemedical equipment to a central hub with specialist nephrologists on duty. Finally, patients on dialysis who value the added security and safety of being telemonitored by their physician might make private payments. Here, too, is a potential for expanding home telehealth.

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