Hospital admission risk program (HARP)
Technology working party report


Victoria
The Place To Be

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March 2003

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Preface

The Hospital Admission Risk Program (HARP) was established in 2001 as the prevention component of the Hospital Demand Management (HDM) Strategy.

The HARP Reference Group, chaired by Professor John Funder, oversees the implementation of HARP, including the allocation of funds to service providers, and advises on how hospital admissions and emergency department presentations can be prevented. HARP focuses on tertiary prevention – that is, avoiding unnecessary emergency presentations and hospital admissions and readmissions. HARP targets people who have manifest health need, often where their disease or condition is chronic or complex.

In July 2002, the HARP Reference Group formed seven working parties to undertake analysis in priority areas that provide opportunities to have a significant impact on preventing the avoidable use of hospitals.

These working parties were:

- Chronic Heart Failure Disease Management
- Chronic Obstructive Pulmonary Disease Management
- Community/Hospital Interface
- GP/Hospital Interface
- Integrated Care for Clients with Complex Needs
- Mental Health
- Technology.

This report presents the findings of the Technology Working Party.

The working party reports build on the information presented in the HARP Background Paper and have been produced to assist in designing projects for the 2003–04 HARP funding round.

The Department of Human Services would appreciate any comments, suggestions for further work or other feedback you may have on the contents of the working party reports. These can be forwarded to the HARP Project Officers, Ian Coverdale at ian.coverdale@dhs.vic.gov.au or Paul Williamson at paul.williamson@dhs.vic.gov.au and will be considered as we further develop the evidence around preventive initiatives.

Acknowledgements

This report was produced by the Technology Working Party of the HARP Reference Group, supported by Ian Brown and Andrew Smale (Monash University Centre for Biomedical Engineering) and Carole Staley (Everitt Anderson Corporation). This working party included:

- A/Prof John Rasa (Chair) — Eastern Health
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- Dr Branko Cesnik — Centre for Medical Informatics
- Mr Alex Currell — Metropolitan Ambulance Service
- Ms Sue Daly — Department of Human Services
- Ms Di Dixon — Western Health
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- Dr Susan Sdrinis — Department of Human Services
- Ms Jannie Selvidge — Barwon Health
- Ms Lyndie Spurr — Royal District Nursing Service
- Mr Paul Williamson — Department of Human Services

We thank members of the HARP Reference Group and the HARP Departmental Steering Committee for their suggestions and contributions to the report.

We have verified the information in this report to the best of our ability. We would appreciate you informing us of any errors or omissions, by email to paul.williamson@dhs.vic.gov.au

Contents

Glossary

Ambulatory patient monitoring	The use of information and communications technology to monitor the medical condition of individuals who are in transit or mobile.
Disease management	The approach of managing chronic illnesses that focus on systematised evidence-based practice and better coordinated care. (See 4.1.1 for disease management models of care.)
E Health	Broad definition that describes the general application of information and telecommunications technology (IT&T) in the area of health.
First generation telemedicine	Essentially high cost videoconferencing-based technology.
Home-based patient monitoring	The use of information and communications technology to monitor the medical condition of individuals who are receiving medical care at home.
Home remote patient monitoring	The use of information and communications technology to monitor the medical condition of individuals who are at home, some distance from the health care provider.
Multi parameter patient monitoring	The measurement of more than one parameter for the purpose of monitoring the medical condition of individuals.
Remote patient monitoring	The use of information and communications technology to monitor the medical condition of individuals who are some distance from the health care provider.
Telecare*	The use of information and communications technology to provide **health care services** to individuals who are some distance from the health care provider.
Teleconsultation	The use of information and communications technology to **conduct a medical consultation with** individuals who are some distance from the health care provider.
Telehealth*	The use of information and communications technology to provide **health services** to individuals who are some distance from the health care provider.
Telemedicine*	The use of information and communications technology to provide **medical services** to individuals who are some distance from the health care provider.

* The definitions for Telecare, Teleconsultation, Telehealth and Telemedicine are similar and have in fact evolved over time.

Abbreviations

CHF	Chronic heart failure
COPD	Chronic obstructive pulmonary disease
DHS	Department of Human Services
ED	Emergency Department
ECG	Electrocardiograph
EPC	Enhanced Primary Care (Medical Benefits Scheme)
EU	European Union
FDA	Federal Drug Administration
GP	General Practitioner
GHQ	General health questionnaire
HARP	Hospital Admission Risk Program
HDM	Hospital Demand Management
HITH	Hospital in the Home
IEEE	Institute of Electrical and Electronics Engineers, Inc
IT&T	Information technology and telecommunications
MBS	Medical Benefits Scheme
RACGP	Royal Australian College of General Practitioners
RPM	Remote Patient Monitoring
SMS	Short Message Service (for sending text messages to mobile telephones)
TIE	Telemedicine Information Exchange (National Library of Medicine, USA)
TIS	Telemedicine Information Service (British Library, UK)
TM/HBPC	Team Managed Home Based Primary Care (Department of VA, USA)
UNSW	University of New South Wales

Executive Summary

Home care based disease management programs in general, and home care based Chronic obstructive pulmonary disease (COPD) and Chronic Heart Failure (CHF) disease management programs in particular, are identified in the recent literature as potentially being likely to benefit significantly from the application of telemedicine [1]. The complexity of these two diseases suggests that it is unlikely that one approach and one technology will suit all situations, and the fact that several models of care are being trialed and evaluated only adds to the complexity of the system of care needed.

One component of this system is Remote Patient Monitoring (RPM) equipment, which helps to provide a profile of the individual patient's medical condition while they are cared for at home. Commercially there is an extensive range of RPM technology available (see section 3.3), which suggests the need to match the technology requirements of a disease management program to the menu of technologies available. The US Department of Veterans Affairs expresses a strong commitment to RPM technology as an important component in programs that aim to allow patients with chronic diseases to be cared for in their homes, and has embarked on a program to evaluate several different technologies.

A strong evidence base confirming the effectiveness and cost-effectiveness of this RPM technology is not yet available, as is the case for most telemedicine applications [2].

However, this report identifies a number of principles, which are identified in the significant body of literature reporting on RPM and telemedicine trials. These principles are not a substitute for an established and evaluated implementation model, however, they provide guidance to those who wish to introduce RPM technologies to disease management models being trialed. It is only by conducting such trials and evaluating the outcomes of using RPM technology in clinical trial settings that a body of experience will emerge. This strongly suggests the need for a coordinated approach where information at all levels (such as planning, implementation, evaluation, patient acceptance, effectiveness) is shared.

The starting point perhaps is sharing information relating to the available technology, its specification, and experience in its use in other programs, to improve technology literacy. This kind of information sharing is a feature of two international telemedicine project databases – the Telemedicine Information Exchange (TIE), based in the USA [3] and the Telemedicine Information Service (TIS), based in the UK [4]).

The report also presents a general implementation model that identifies technology requirements, shows information flows and identifies stakeholders. This model may be tailored to the requirements of a particular model of care, a particular disease and/or a particular RPM technology. It aims to help identify the relationship between these aspects. This section of the report also provides a checklist for RPM implementation proposals and identifies common features of RPM systems reported in the literature.

This report is not a comprehensive review of the available literature. However, it does identify reports and papers on RPM projects that involve CHF and COPD patients, telemedicine projects that involve patient monitoring, emerging monitoring technologies used in telemedicine, and available RPM technology. Systematically collected, this body of knowledge should assist in improving the understanding of health professionals who wish to become involved in RPM as it emerges. An analysis and discussion of the literature is also presented.

After consideration of the literature and findings from a key informant workshop, the Technology Working Party proposes the following recommendations:

1. RPM should be considered in relation to existing projects for the management of chronic disease in situations where the introduction of technology is likely to improve the clinical outcomes, make better use of available resources, and improve patient involvement in their care. In proposals for the use of RPM technology, the perceived benefits of using RPM technology should be specified in relation to these terms.
2. It is strongly recommended that RPM technology be piloted with established COPD and CHF projects so that this experience can be used to inform broader implementation in the future. Technology requirements should therefore be written to support disease management project requirements.
3. The implementation model outlined in section 5.3 be used as a template to ensure comprehensive consideration of the relevant stakeholders, information flow and technology issues. An RPM Implementation Checklist is provided in section 6.2 to assist this process.
4. That HARP disease management projects embarking on the introduction of RPM engage the required technical support for the establishment of technology requirements, for undertaking effective:
   - system design
   - selection of technology
   - implementation.
5. That HARP disease management projects embarking on the introduction of RPM take into consideration the telecommunications infrastructure requirements for effective communication. (It is noted that the 'Health Tel network' available for both acute and primary care applications would provide the bandwidth and speed needed for the more advanced RPM applications.)
6. That all disease management projects that introduce RPM technology undertake to evaluate the proposed project in relation to patient outcomes; quality of care; cost-effectiveness; patient involvement in disease management; and better use of available resources.

7. That HARP project participants continue to monitor RPM technology developments and the emergence of evidence relating to the evaluation of new technology, and share learnings to raise the knowledge base statewide and amongst HARP project participants.
8. That an evaluation of commercially available technology be undertaken by an independent evaluator to establish its technical, clinical and safety characteristics in the contexts of the management of CHF and COPD patients. The purpose of this evaluation is to assist clinicians in the selection of appropriate and safe commercially available RPM technology.

1. Background

Demand for public hospital services is growing consistently at 3–4 per cent per annum, both in Victoria and other states. For the 12 metropolitan hospitals across Melbourne with emergency departments (EDs), emergency admissions are growing at 7–8 per cent per annum. This emergency demand pressure has driven the growth in ambulance bypass and longer waits in EDs.

There are a number of factors contributing to demand growth, including the ageing population, new treatment options through advances in medical technology, a reduction in the availability of general practitioners (GPs) for home visits and after hours care, and societal changes that have led to a reduction in the capacity of the informal carer network in the community.

The other side of the equation is the capacity of hospitals to respond to demand. Concurrent with the demand growth, there have been constraints on Victorian hospital capacity associated with:

- beds–Victoria has a lower per capita number of residential aged care beds compared with other states
- nurses–workforce issues have meant that there has been a shortage of nurses to staff services.

1.1 Hospital Demand Management Strategy

The combination of demand growth and capacity constraints has resulted in an imbalance between supply and demand within the health care system. A new approach, the Hospital Demand Management (HDM) strategy, is creating additional capacity to meet the demand pressures. The Victorian Government has committed $582 million over four years to this strategy. Key aspects of this strategy include:

- creating extra capacity through funding growth
- relieving pressure on acute hospital beds and EDs through diverting people to alternative options where clinically appropriate
- working with clinicians to achieve better patient management practices through negotiation of a tailored response with each hospital
- improving working conditions that will attract and retain nurses
- implementing a prevention strategy to reduce the demand pressures on hospitals (known as the Hospital Admission Risk Program or HARP).

The HDM Strategy focuses on the service system as a whole rather than on fragmented interventions or single organisations. It promotes appropriate pathways for people using health services and encourages models of care that respond to current demands for health services. Collaboration between health providers is emphasised within this strategy.

1.2 Hospital Admission Risk Program

The importance of prevention within the HDM Strategy has been highlighted with an allocation of $150 million over four years. HARP aims to avoid unnecessary use of EDs and inpatient services in the hospitals participating in the HDM Strategy. The primary objective of HARP is to implement models of care that better manage emergency presentations and emergency admissions to public hospitals through alternatives that involve the hospital and the community. This will:

1. Improve people's health outcomes. It is anticipated that enhancements to people's health status and their wellbeing will be achieved through:
   - supporting people's independence and capacity to live within the community
   - increasing capacity within the health system to respond to the health needs of people
   - developing responsiveness in services and proactive management of people's health needs
   - clearer clinical pathways delivering better continuity of care
   - creating cohesion between public hospitals, the sub-acute and primary care sectors.
2. Reduce preventable use of EDs and inpatient services in the hospitals participating in the HDM Strategy. It is anticipated that the preventive initiatives funded will have a noticeable impact on the acute health system and will be reflected in one or more of the following outcome measures:
   - a reduction in the rate of growth in presentations to EDs for relevant conditions
   - a reduction in the rate of growth in admissions and readmissions to inpatient services for relevant conditions
   - a decrease in length of stay for those people with relevant conditions who are admitted to hospital.

The specific aims of HARP are to:

- Identify target conditions and/or cohorts of patients with high volume ED presentations and admissions that have potential to be proactively managed in the community.
- Undertake focused literature reviews for high volume conditions to document best practice principles and establish an evidence basis for hospital specific prevention plans.
- Develop specific prevention plans around hospitals participating in the HDM Strategy.
- Engage clinicians in driving major clinical practice change for target conditions.
- Contribute to establishing a collaborative and cooperative preventive approach between all sectors of the public health care system.

- Oversee implementation of hospital specific plans.
- Establish condition specific network(s) to share information with all participating sites.
- Coordinate evaluation of funded projects.

1.2.1 The HARP Reference Group

HARP is a collaborative strategy between hospitals, GPs, community providers, key clinical groups, consumers, research bodies and the Department of Human Services.

Reflecting this, a HARP Reference Group has been established. This group is chaired by Professor John Funder and brings together a range of stakeholders with an interest and relevant expertise in the area, including clinicians, primary health providers, GPs, health service administrators, consumers and carers, researchers and the Metropolitan Ambulance Service, to provide strategic direction and monitor implementation of HARP.

The reference group will consider and provide advice on:

- target population groups or conditions with most potential for preventing hospitalisations
- trends in morbidity and care options
- best practice for management of patients
- models of care that have demonstrated efficacy
- evaluation of initiatives funded.

Additionally, the Secretary of the Department of Human Services, Ms Patricia Faulkner, has established a HARP Departmental Steering Committee that is chaired by the Executive Director of Metropolitan and Aged Care Services, Mr Shane Solomon. This committee brings together representatives from relevant parts of the department to oversee the implementation and ongoing evaluation of HARP and to ensure that a whole of department approach is achieved. The reference group reports and provides advice to the steering committee. Professor Funder, as the chair of the reference group, is a member of the Departmental Steering Committee.

In July 2002, the HARP Reference Group established the following seven working parties to undertake detailed work in priority areas that provide opportunities to have a significant impact on preventing the avoidable use of hospitals:

- The Community/Hospital Interface Working Party
- The GP/Hospital Interface Working Party
- The Technology Working Party
- The Integrated Care for Clients with Complex Needs Working Party
- The Chronic Heart Failure Working Party
- The Chronic Obstructive Pulmonary Disease Working Party
- The Mental Health Working Party

These working parties are chaired by members of the reference group and report back to the reference group.

1.3 The Technology Working Party

There has been an explosion of new technology in the telemedicine arena in recent years. Among these developments are the use of telephone and email to provide advice to patients, the capacity to undertake consultations via video-link (for the purposes of both diagnosis and ongoing review), the use of computers to view and assess radiology films from a distance, the use of digital photography of skin lesions which can be emailed to a specialist for diagnosis, and the transfer of information from implanted cardioverter defibrillators scanned by a patient down a phone line and accessed by a cardiologist.

The HARP Technology Working Party was established to explore opportunities for advancing the use of technology to assist in disease management programs. In particular, the working party examined remote monitoring of patients with chronic and complex illnesses, focusing on COPD and CHF.

1.3.1 Objectives

The objectives of the Technology Working Party were to:

1. Review remote monitoring technologies.

2. Identify opportunities for the utilisation of remote monitoring technologies within HARP projects.

3. Provide a report to the HARP Reference Group about the use and utility of remote monitoring technologies.

1.3.2 Consultants

Consultants for this project were Everitt Anderson Corporation Pty. Ltd. (Ms. Carole Staley) and Monash University Centre for Biomedical Engineering (A/Prof. Ian Brown and Mr. Andrew Smale).

1.3.3 Purpose of the project

The purpose of the consultancy project was to support the working party in its consideration of remote monitoring technologies, with a focus on disease management and, in particular, CHF and COPD.

The key tasks were:

- undertake a literature review of remote monitoring technologies, with a specific focus on disease management applications
- identify stakeholders within current HARP projects and the broader industry who have an interest in or experience of remote monitoring technologies
- consult with relevant stakeholders about the use and utility of remote monitoring technologies, particularly for COPD and CHF

- analyse issues raised in the literature and by the stakeholders
- discuss the options for the application of a remote monitoring model in the context of existing and future HARP projects.

1.3.4 Methodology

The main methods of data collection involved:

1. a literature review
2. a survey of HARP stakeholders
3. a Remote Patient Monitoring Technologies Workshop
4. other stakeholder consultations
5. a commercial technologies search.

1.3.4.1 Literature review

A systematic literature search was undertaken to identify research papers dealing with RPM (full details of the search methodology are provided in Appendix B). Literature on this topic is found in a wide range of publications including:

- medical publications dealing with CHF, COPD and disease management applications
- IT publications dealing with medical informatics issues relating to telemedicine
- biomedical engineering publications dealing with emerging RPM technologies and technologies that support telemedicine
- telemedicine publications dealing with both RPM technology and the broad issues relating to telemedicine and enabling technologies.

The literature search was largely restricted to:

- post-1995 publications
- medical publications relating to COPD, CHF and disease management applications and technologies (Current Contents and Medline databases were reviewed)
- IT and biomedical engineering publications relating to RPM – (the IEEE Explore database was reviewed)
- Telemedicine publications for dealing with the broader range of issues – (Telemedicine Journal and e-Health and Journal of Telemedicine and Telecare were comprehensively reviewed).

1.3.4.2 HARP stakeholder technology survey

A limited survey of HARP stakeholders was undertaken to establish baseline levels of interest and knowledge in the area of RPM. The results of this survey were presented to the Technology Working Party RPM workshop held in November 2002, and are presented in section 3.1 of this report.

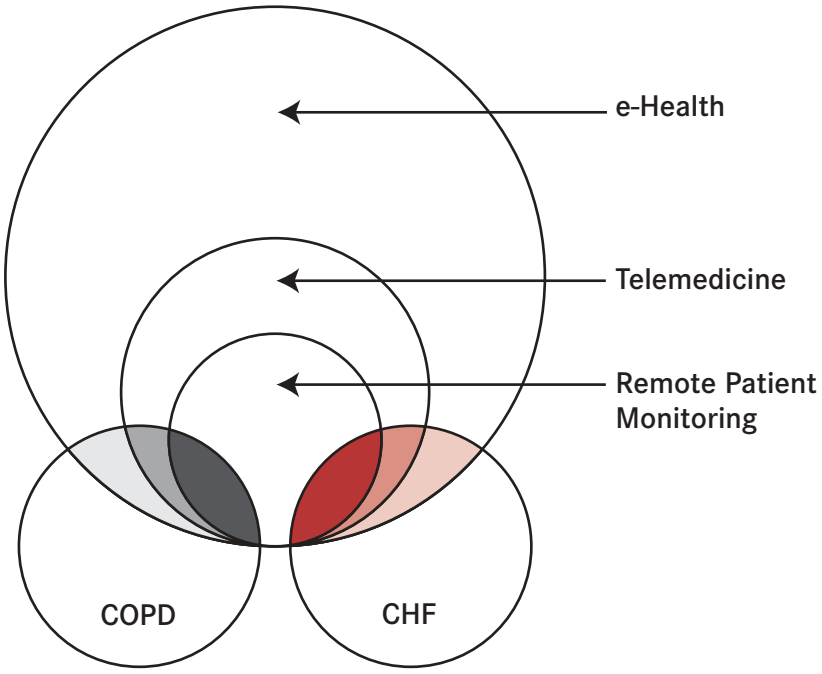
1.3.4.3 Remote Patient Monitoring Technologies Workshop

In relation to its consideration of relevant technology for the remote monitoring of patients with COPD and CHF, the HARP Technology Working Party conducted a half-day workshop on remote monitoring technologies.

The objectives of this workshop were to:

- identify available and emerging RPM technologies
- identify opportunities for the utilisation of RPM technologies within HARP projects
- identify and address issues relating to the implementation of RPM technologies
- foster sharing of information between participants to encourage the use of RPM technologies for patients with COPD and CHF.

Figure 1.1: Relationship of remote patient monitoring for COPD and CHF to telemedicine and e-health.



1.3.4.4 Other stakeholder consultations

Subsequent to the workshop, a number of HARP project participants were contacted by telephone to follow up issues raised at the workshop.

1.3.4.5 Search of commercial technologies

Commercial RPM technology suppliers were identified using existing contacts with medical equipment suppliers and data provided by new telemedicine equipment suppliers listed on the Internet.

1.3.4.6 Analysis of data and reporting

The consultants worked closely with the Technology Working Party in discussing the literature, working through issues and in the development of the final report.

1.4 Definitions of remote patient monitoring

A number of related terms have emerged within the literature and are introduced in the Glossary of this report. The relationships between the definitions are dealt with here to illustrate where home remote monitoring sits in relation to monitoring technologies, and where treatment for COPD/CHF sits in relation to health care. These relationships are illustrated in Figure 1.1 above, and discussed in the following sections.

1.4.1 E-health

Electronic health, or e-health, is a subset of e-commerce and is a broad definition that describes the general application of information and telecommunications technology (IT&T) in the area of health. E-health is not simply about business transactions; it deals also with medical informatics generally and medical technology in particular. E-health is the umbrella field that encompasses telehealth [5].

1.4.2 Telemedicine

Telemedicine is the use of information and communications technology to provide medical services to individuals who are some distance from the health care provider. Mitchell [5] defined telemedicine as consisting of the following common elements:

- the delivery of health services
- at a distance
- through the transfer of information, including audio, video, and graphic data
- using telecommunications
- involving a range of health professionals, patients and other recipients.

Mitchell also pointed out that telemedicine for some people suggests medicine and, therefore, doctors and that telehealth has emerged as a term that includes a wider range of health professionals.

1.4.3 Telehealth

Telehealth is often used to emphasise the provision of health services, as opposed to medical services. The health services may be provided by a range of health care disciplines and involve education and self-management aspects of disease.

1.4.4 Health informatics

The Health Informatics Society of Australia defines health informatics as an evolving scientific discipline that deals with the collection, storage, retrieval, communication and optimal use of health-related data, information and knowledge.

1.4.5 Remote patient monitoring

RPM represents the intersection of patient monitoring and telemedicine (or telehealth) and is a subset of telemedicine. Almost any parameter of a patient's medical condition that can be monitored through the use of telecommunications can be monitored remotely. This includes monitoring patients in remote rural hospitals or aged care centres, in transit in ambulances, at home or, for that matter, anywhere in the community. Such monitoring can involve any technology from the simple telephone to sophisticated wireless telemetry systems that continuously monitor vital signs. Such technology can be used for diagnosis, treatment, immediate intervention, or longer term disease management.

1.4.6 Home remote patient monitoring

Home remote patient monitoring (HRPM) is a subset of RPM and involves monitoring parameters of a patient's medical condition while the patient is at home. Again, such monitoring can involve any technology and can be used for diagnosis, treatment, immediate intervention or longer term disease management.

1.4.7 Disease management

Disease management is an approach to managing chronic illness that focuses on systematised evidence-based practice and better coordinated care. The approach aims to better manage the growing number of patients with complex chronic diseases, such as CHF, COPD and diabetes. The literature suggests that disease management for some patient groups would significantly benefit from the use of telemedicine and home-based patient monitoring.

1.4.8 Chronic Obstructive Pulmonary Disease

COPD is the collective term for a number of lung diseases that prevent people from breathing properly. Two of the most common types of COPD are emphysema and chronic bronchitis. These conditions often occur together. The main symptom is breathlessness, since the airways of the lungs are damaged, clogged with phlegm and unable to work efficiently. Cigarette smokers are most at risk. COPD used to be more common in men, but the disease is quite evenly spread across the sexes now that women smoke in equal numbers to men. There is no cure for COPD, and the damaged airways don't regenerate. Treatment aims to prevent further damage, reduce the risk of complications and ease some of the symptoms.

The symptoms of COPD include:

- breathlessness after exertion
- in severe cases, breathlessness even when at rest
- wheezing
- coughing
- coughing up sputum
- fatigue
- cyanosis
- increased susceptibility to chest infections.

1.4.9 Chronic Heart Failure

CHF is present when the heart cannot pump enough blood to satisfy the needs of the body. Weakened chambers allow blood to pool inside the heart and nearby veins. This triggers fluid retention, particularly in the lungs, legs and abdomen. The major causes of heart failure include coronary heart disease, hypertension, cardiomyopathy and other heart diseases. Of these, coronary heart disease (usually accompanied by a history of past heart attacks) is by far the most common. The major factors that contribute to coronary heart disease include:

- obesity
- a diet high in saturated fats and cholesterol
- high blood pressure
- diabetes
- smoking
- physical inactivity.

CHF is more common in the elderly. The survival rate for people with this disorder depends on the severity of their condition. Treatments include medication, lifestyle changes and, sometimes, surgery.

Symptoms of CHF include:

- undue breathlessness during activity
- breathlessness at rest or on doing light exercise
- muscular fatigue, tiredness
- swelling of ankles or legs
- swelling of abdomen
- unexplained coughing and wheezing.

2 Summary of literature

A systematic literature search was undertaken to identify research papers dealing with RPM (full details of the search methodology are provided in Appendix B). Relatively few articles were found discussing the issues of home monitoring in the target disease groups of COPD and CHF. Home monitoring for chronic disease management is a relatively new area of health care, so articles cover earlier stages of development, such as prototype design descriptions of devices and pilot stage testing of systems. In general, these articles predominantly cover:

- home monitoring for other disease groups apart from COPD and CHF (mainly diabetes [6–10] and asthma [11–14])
- home monitoring of aged patients for activities of daily living, to detect abnormal behaviour which could indicate assistance is needed, for example, a fall [15–18]
- home monitoring for more acute applications, particularly real-time and store-forward monitoring of vital signs at home or in the ambulance [19–39]
- replacement of in-person home nurse visits with telemedicine visits, typically by videophone [40, 41].

2.1 Home monitoring – general issues

Many of the articles contain discussion of issues for home monitoring that can be applied to long-term monitoring for chronic disease management. Common themes for long-term monitoring of chronic patients in their homes are:

- The aim is to promote patient compliance with their care plan, with the goals of avoiding hospitalisations and improved quality of life [42].
- Project justification, planning and implementation must be sound for long-term success and sustainability [9, 43].
- The planning of any telemedicine project deserves significant effort. A wide variety of design, implementation and evaluation issues must be considered [43–84]. Human factors tend to determine the success or failure of telemedicine projects, not technical factors [82].
- Patient satisfaction and the technology human interface must be considered, both for the patient at home and for clinicians using the collected data [85–87].
- Patient privacy must be maintained [88–92].
- The review of the collected data needs to follow a process, which may need to be automated in cases of large amounts of data [93, 94]. Collected data should inform existing care plans, not drive them.
- Projects must become part of normal care practice for long-term success [82, 95].
- Measures of success need to be defined, and project evaluation should follow accepted guidelines [2, 42, 58–60, 79, 81, 82, 96] (see also section 2.5).

- Collaboration and information sharing plays an important role in developing the relatively young field of telemedicine applications for chronic disease management [82].
- Ethics and medicolegal issues warrant specific attention [90–92, 97–108].

2.2 Home monitoring – CHF

There were 33 articles found that discussed home monitoring of CHF patients [21, 109–140]. There are two main areas of investigation being reported in the literature in relation to home-based monitoring of CHF patients. These two areas deal with the range of technologies used in disease management programs and trials of home-based monitoring. Additionally, some other predominantly non-technology issues are reported.

2.2.1 Range of technologies

There are overseas reports of the use of innovative programs of disease management to reduce rehospitalisation rates. These programs have been motivated by changes in the reimbursement schemes for CHF patients in acute hospitals, and have led to multidisciplinary management teams and patient education programs. The issue of long-term patient compliance with treatment paths has been tackled in a variety of ways.

At the Valley Baptist Medical Centre in Texas, regular weekly telephone calls are scheduled from the case manager, in which subjective information is requested from the patient [139]. No patient measurements are reported.

In another case, at Evanston Northwestern Healthcare, Illinois, patients call daily at noon to a toll free number to record their status on a computerised telephone system [128, 140]. Information includes subjective daily symptom scores and body weight.

In both cases good patient compliance with disease management is reported, although patients who are likely to have difficulty complying are excluded. These reports indicate a range of possible technologies that can be used for ongoing monitoring of patient compliance within CHF management programs. The literature does not report any comparisons between the various technologies to rate their relative success, cost or suitability in particular patient groups.

Store-forward systems located in the patient's home that interface to a variety of patient measurement devices are also available [113, 141, 142]. These systems may be based on a personal computer with a custom software package or other intelligent device to direct the testing process and transfer measurement data to a central database for analysis. These systems can be configured for the particular needs of the patient or project, and offer recording for combinations of spirometry, ECG epochs, non-invasive blood pressure and body weight. They can also perform patient education and medication diary/reminder tasks and, in some cases, include videoconferencing capabilities.

2.2.2 Trials of home-based monitoring

There are limited reports of trials of home-based monitoring of physiological parameters in order to improve patient compliance with treatment regimens. No major multi-centre randomised trials have been reported. There are two pilot studies reported, and a report of a large trial that is underway but not yet concluded.

de Lusignan (1999)[114] reports a controlled pilot of 20 patients over three months, conducted in London. Pulse, blood pressure and body weight were recorded and stored in a 'home-hub' computer in the patient's home, then forwarded on to the central database server using ordinary phone lines. A videophone was also available in the system. Results after one year of this study are reported in de Lusignan (2001)[116], and show that improvements in outcomes were obtained for the telemonitored group but that video consulting was not successful in the long-term, perhaps because it was unnecessary:

> Compliance with measuring weight, pulse and blood pressure remained high throughout the study. The data collection system and secure web-server were reliable. The telemonitoring group complied better with collecting prescriptions for their cardiac drugs. Video consulting started with enthusiasm, but became less useful. There were no significant differences in the quality of life (GHQ) and Chronic Heart Failure (Guyatt) questionnaire scores between the telemonitored group and the controls. CONCLUSIONS: Home telemonitoring is an acceptable reliable intervention. Baseline rates for compliance with self-monitoring are set out in this study. Benefit in terms of compliance with medication and self-monitoring is still seen after 1 year. Video consulting over ordinary telephone lines did not show sustained benefit, and was not complied with.

The usefulness of video consulting for CHF patients is also questioned in Jerant (2001)[125]. In this pilot, conducted by the University of California Davis School of Medicine, Sacramento, 37 patients were randomised into three treatment paths – 1) telecare (video consulting with an incorporated electronic stethoscope); 2) telephone interviews with the nurse; and 3) usual outpatient care. After six months, both the telecare and telephone groups showed improved outcomes over the control group, but there was no obvious difference between the video-based home telecare and telephone care groups for any outcome. They suggest that CHF home care may be largely 'non-visual' and that telephone communication is adequate. Video telephone equipment does not currently offer sufficient resolution to detect subtle changes in oedema status. A much larger trial would be required to differentiate the two technology interventions.

On the other hand, Kaiser Permanente in Sacramento, California conducted its own study with patients diagnosed as having CHF, COPD and other home-based management conditions, and concluded that 'enough evidence exists to justify incorporating Tele-Home Health as a model of care within the Kaiser Permanente organization' [126]. In this quasi-experimental study, newly referred patients who

met the inclusion criteria were offered an opportunity to participate. The control group consisted of 110 patients who received routine home health care (home visits and telephone contact), while the intervention group of 102 patients also had access to a video telephone system which included peripheral equipment for assessing cardiopulmonary status. As a result of this study, the videophone-based care will be part of the standard plan of care for identified patients, and about half the visits will be made by remote video.

In all studies, patient and carer education forms a major part of the home management program, to enhance the transition to effective patient self-management.

2.2.3 Australian studies

Home-based management of CHF patients has been studied by Stewart et al. at Queen Elizabeth Hospital in Adelaide (1998, 1999, 2002)[136–138]. These reports discuss aspects of home-based interventions for CHF patients after discharge from acute hospital care. Home-based intervention consisted of a single home visit at one week after discharge by a nurse and pharmacist to optimise medication management, identify early clinical deterioration, and intensify medical follow-up and care-giver vigilance as appropriate. No monitoring technology was used for long-term compliance monitoring. This intervention was found to be associated with reduced frequency of unplanned readmissions within six months of discharge [136], and this benefit was sustained for at least 18 months [137]. The home-based intervention was further studied for detection of early clinical deterioration within 14 days post-discharge in CHF patients, particularly for older 'high-risk' patients [138].

A general review of telehealth applications in cardiac care was conducted in 2001 by Hooper et al. of the Centre for Online Health at the University of Queensland [121]. This review investigated both diagnostic and disease management aspects of telehealth suitable for cardiac patients, and found that telemedicine cardiac applications appear suitable for providing both service extensions and cost-effectiveness. However, further cost-effectiveness data is still needed before such telehealth programs can be implemented on the basis of real evidence.

Perhaps of most relevance is the study undertaken by the General Practice Computing Group of the Royal Australian College of General Practitioners (RACGP) [94]. In this study, both CHF and COPD patients located in Sydney and Wagga Wagga were provided with a home monitoring station developed by the University of New South Wales (UNSW) Centre for Health Informatics. Patients recorded various physiological parameters relevant to their individual condition daily and answered subjective questions about their wellbeing on the home station, and then transferred these data to a central database server for review by their local GP. GPs received regular email updates of the progress of their patients with indications where interventions may be required. Detailed views and trends of patient results were available over a secure Internet connection for Web browsers.

During this pilot study, 25 advanced prototype units were manufactured and placed with patients for between six and 12 weeks. The project demonstrated that the system was acceptable to patients and clinicians and able to produce high quality reliable data. Further analysis of outcomes has not been reported, although the system is being considered for further commercialisation. Recommendations included that the system be subjected to a major controlled clinical trial and that a robust medical expert system be developed to assist with the analysis of data collected.

2.2.4 Other related reports

There are two reports that are not directly related to home-based monitoring of CHF patients for the purposes of long-term compliance monitoring but are of interest.

Home monitoring technology has been used for continuous wireless cardiorespiratory monitoring of CHF patients to detect Cheyne-Stokes respiration [109]. In this application the monitoring is used in a diagnostic application rather than for long-term disease management.

In another home monitoring study for hypertensive patients [111], daily recording of patient blood pressure, heart rate and body weight was undertaken with the goal of stabilising blood pressure. In this pilot study of 33 patients, the receiving station for the patient data was located in a hospital cardiac surveillance unit alongside the inpatient cardiac telemetry system central monitor, providing 24-hour response to any alarm conditions raised.

2.3 Home monitoring – COPD

There were 23 articles found that discussed home monitoring of COPD patients [85–107]. However, the bulk of these reports relate either to the treatment of acute exacerbations of COPD with the patient discharged to their home for 'hospital in the home'-type acute management until the exacerbation has been treated [143–148], or relate to trials of treatment options for acute exacerbations [149–151]. Longer term management of COPD illness is also discussed in relation to patient education and self-management [152, 153] and quality of life issues [154]. These reports are considered not directly relevant for home monitoring for the purposes of long-term chronic disease management.

The cost-effectiveness of hospital outreach programs involving home nursing visits for COPD patients is investigated by Smith et al. [155], but there is no discussion of technology for monitoring. Such nursing visits are shown to be suitable for replacement by telenursing visits (involving video conferencing and telemetry monitoring data transmission for immediate review during the virtual visit), subject to eligibility criteria, by Allen et al. [156].

The cost-effectiveness of a telepulmonary program for linking a remote rural medical centre to a large city medical centre was evaluated by Agha et al. [157], but this program did not involve patients in their homes.

2.3.1 Range of technologies

Technologies for COPD management were either simple spirometer devices with data storage and telephone connection for data transfer (spirophones) or personal computer-based spirometer devices with real time display of flow-time and volume-time curves and the ability to provide other patient management tasks such as administering subjective questionnaires and providing educational material. Spirometers are also reported commonly with the management of asthma, while one system used SMS text messaging to patients' mobile phones [158].

Data collection for COPD disease management is also being conducted via computer automated telephone conversations [159]. In this application the computer system (called TLC-COPD) engages patients in regular automated telephone conversations between their office visits to their physicians, using computer-controlled speech to ask patients questions. Patients respond via the telephone touch-tone keypad and the computer system provides feedback. The system functions as an at-home monitor, educator and counsellor.

Spirophones have been shown to have at least initial accuracy when compared to laboratory spirometers according to the American Thoracic Society testing guidelines [160]. However, issues of long-term calibration, equipment reliability and patient self-testing repeatability have not been reported.

Personal computer based store-forward systems with more complex functionality have been described by Morlion et al. from Belgium [14] and Lovell et al. from the UNSW Centre for Health Informatics [141]. These systems can be configured for a variety of medical peripherals according to the needs and complexities of the patient – spirometry, ECG epoch recordings, non-invasive blood pressure, and body weight being the most commonly available.

2.3.2 Home-based management trials

The Department of Veterans Affairs in the USA is undertaking significant studies in the home-based management of chronically ill patients. The Team Managed Home-Based Primary Care (TM/HBPC) study involved 1,966 patients over four years in 16 Veterans Affairs medical centres, with patients with CHF, COPD or other chronic illness [161]. This multicentre randomised controlled trial found that quality of life improvements were delivered for patients and their carers, but at higher care costs. No technology for regular home monitoring was reported.

There is a lack of reports of trials investigating the use of home monitoring technology for the long-term management of COPD patients. However, a number of the systems, described in section 2.3.1, have undergone pilot study evaluation.

The spirophone equipment has been evaluated in a 10 patient pilot study, and daily spirometry was shown to allow early recognition of pulmonary infectious exacerbations in patients with cystic fibrosis [162].

The automated telephone system (TLC-COPD) is currently being evaluated in a randomised controlled trial that was due for completion in 2001 [159].

The personal computer based home monitoring system developed by the UNSW Centre for Health Informatics [141] has been subject to pilot study evaluation, as discussed in section 2.2.3.

Further, a home-based unit for chronic respiratory patients that can record blood pressure, blood oxygen saturation, ECG, spirometry flow-volume curves and respiratory rate is being evaluated in a pilot study due for completion in December 2001 [163, 164].

2.4 Evidence base

There were seven articles found that discussed the evidence base for showing clinical and cost effectiveness of telemedicine projects [165–171].

Systematic reviews such as these focus on efficacy, effectiveness, cost-effectiveness and patient satisfaction, and comparisons with conventional means of service provision.

These reports consistently show that while there is convincing evidence for the use of telemedicine for particular applications (namely teleradiology, telepsychiatry, teleneurosurgery, teledermatology, and some others), in general telemedicine literature refers mostly to pilot projects and short-term outcomes. It can be seen from the above sections, home monitoring telemedicine projects are no exception to this conclusion.

These reports recommended that the implementation of new telemedicine services should be linked to realistic development of a business case and subsequent data collection and analysis.

2.5 Assessment of telemedicine projects

There were 25 articles found that discussed the assessment and evaluation of telemedicine projects [43–45, 50–54, 58–63, 67, 68, 71, 74, 77–79, 81, 83, 172, 173].

Evaluation (or assessment) of telemedicine projects has been discussed extensively in the literature, as it is a complex area and every evaluation process has its own objectives. Some projects require ongoing evaluation as part of a quality control monitoring process, while others have the goal of demonstrating economic improvement or clinical improvement over the alternative (non-telemedicine) treatment method.

As the scope of evaluation can be very broad, it is important to define what level of evaluation is required, what measures constitute success, and that sufficient resources are allocated and planned to undertake the evaluation when designing the project. Frameworks for developing assessment objectives and methodologies are given in [51, 52, 58, 59, 61, 67, 83, 172, 173] and commonly include the following important areas [59]:

1. Specification of the clinical requirements and technology being considered.
2. Establishment of performance measures for
   - time taken to perform various tasks
   - quality of service
   - cost of service provision, including start-up costs and ongoing costs.
3. Establishment of health outcome measures.
4. Establishment of summary measures, such as cost-effectiveness of cost-comparison.
5. Evaluation of operational and other considerations, such as:
   - access to health care
   - acceptability to patients, clinicians and managers
   - legal issues.

Evaluation of telemedicine projects is highly complex and is often underestimated [68]. These findings suggest there is value in the use of common reporting and evaluation methods for future projects to promote information sharing and learning.

2.6 Emerging technologies and future issues

Currently available technologies for long-term home monitoring of COPD and CHF patients are based on existing telecommunications infrastructure. Devices being researched for the use in the future will make further use of wireless data transfer between the medical peripheral and the store-forward device (personal computer or other intelligent unit) located in the patient's home [21, 25, 29, 32, 33, 87, 88, 109, 115, 174-177]. Other devices that connect directly to the mobile telephone system or have a wireless Internet connection [19] are also being researched.

Devices that are used in the patient's home for data collection and provision of education or other self-help services are commercially available for COPD and CHF patients. Although a comparative evaluation of these devices and systems was beyond the scope of this report, the devices are described briefly in section 3.3 and manufacturers are listed in Appendix B.

Patient data is commonly stored in a database system of some description, and often the data is accessible via Web browser over a secure Internet connection. Web browser availability makes implementation of a highly accessible database inexpensive relative to other client-server database systems. Data management, security and patient privacy therefore become significant issues.

Another emerging issue is the need for training in the use of telemedicine systems for clinicians [82]. Support is needed for raising skill levels and technology literacy to allow better use of this new method of health care delivery.

3 Results of consultation process

Consultation with participants of HARP projects and commercial vendors of RPM technology was conducted through:

- Attendance at a Disease Management conference held in Sydney during October 2002, and a workshop on evidence-based medicine and decision support tools – monitoring and controlling disease management.
- Conducting a HARP Stakeholder Technology Survey.
- Conducting a HARP Stakeholder Workshop.
- Follow up with various HARP participants and key stakeholders via telephone and over the Internet.

This chapter provides a summary of the key themes relating to RPM identified by these stakeholders.

3.1 Disease Management Conference, Sydney, October 15, 2002

3.1.1 Conference content

The conference provided a broad overview of the management of chronic disease, covering the following issues:

- availability of information pertaining to diseases and drugs
- communication of diseases and drugs information from industry to consumers
- processes of managing and educating patients about chronic diseases, particularly in relation to asthma and diabetes
- IT infrastructure required to manage patient information
- home telecare technology.

With the exception of the paper outlined in section 3.1.2, there was no focus on technology/medical devices, point of care devices or medical decision support tools. The Decision Support session of the conference largely outlined the general infrastructure and concept of using technology in managing patients and patient information. The presentation made by Mr Paul Sulkers of IBM dealt with the IT infrastructure required for the integration of information, and management of patients and disease.

3.1.2 Conference paper by Professor Branko Celler, University of NSW

The paper presented by Branko Cellar, Professor of Biomedical Engineering, UNSW. titled 'Integration of GP managed home telecare with established clinical services for chronic disease management and ambulatory care' was of particular interest [178].

The technology developed by Professor Celler's team is a personal computer based system consisting of a blood pressure cuff, single channel ECG, spirometer, body temperature probe, weigh scale, motion detector, ambient temperature probe, and on line medication management software, which are all connected to and

interpreted by the computer for presentation of clinical information. Individual patient systems are connected to a centralised monitoring facility via a standard telephone line. This system is discussed briefly in section 2.2.3, and further details of the system are in the conference paper.

A trial of the system has recently been completed. This trial was funded by the Commonwealth Department of Health and Aged Care – General Practice Branch under the tender Information Management and Technology in General Practice 2000-2001 (RTF 31/0001). This system has now been decommissioned due to regulatory and legal liability issues. The trial was reported as being very positive; it was stated that 88.9 per cent of the GPs involved in the trial were satisfied with the system. The remaining 11.1 per cent were neutral about the system. It was also found that rural GPs were more receptive of the technology than city GPs. Extract of the final report on the trial (found on the Web site http://www.chi.unsw.edu.au/ or http://www.gpcg.org) is attached.

The system is currently undergoing commercialisation. It will be marketed by Medcare Pty Ltd (a vehicle for commercialisation of technology products emerging from the Biomedical Systems Laboratory within the University of New South Wales) and would cost around $5,000 to $6,000 per unit.

Although it was indicated that the system is not a propriety system and can operate with other devices, it lacks the capacity for 'plug and play'. The system currently would only operate with devices developed by the team. The software developed appears to be stand-alone. Information obtained by the system would not be easily transferred to other patient management software. The lack of standards in the industry is a major issue.

3.1.3 Summary

The conference and workshop were of great value for management and health care providers. They were focused on the process of disease management, covering issues of patient education, evidence-based medicine, use of technology in the management process, and information resources. The medical technology presented provided an overview on how technology can be used in managing patient information and monitoring a patient's condition and was small part of the overall conference.

3.2 HARP Stakeholder Survey – potential for remote patient monitoring in HARP projects

In preparation for the stakeholder workshop (see section 3.3 below), a questionnaire was distributed to all invitees of the workshop to gauge the level of experience and interest and current perceptions of issues relating to RPM technologies. The responses to the questionnaire are presented in summary form in Appendix D.

There were 12 responses, of which only two reported any experience with using RPM technologies. These two responses indicated they were using RPM

technologies in applications not related to those envisaged for long-term disease management of COPD or CHF patient cohorts.

Nearly all responses indicated a high level of interest with either learning more about RPM technologies or planning their use within current or future projects involving COPD or CHF patient cohorts.

The perceived main benefits for the use of RPM technologies (question 3 of questionnaire) were:

- trend monitoring, leading to intervention before problems escalate
- adjunct and improvement to patient self-management, leading to better compliance with treatment
- improved health outcomes at lower overall cost
- reductions in presentations to hospitals
- higher patient to staff ratios
- patient can be any distance away from doctor
- minimise routine return visits by patients especially from rural areas
- Improvements in disease management – lower costs, improved convenience and quality of life for patients.

The perceived main barriers to the use of RPM technologies (question 4 of questionnaire) were:

- establishment and ongoing costs/funding
- infrastructure establishment and support (eg. telecommunications to remote areas) and other infrastructure
- awareness and computer literacy amongst health professionals, suggesting a need for education and training
- patient compliance with use of technologies; understanding, ability, cultural barriers
- interfaces to other medical systems (patient records)
- data management issues; privacy, data security, back-ups
- lack of outcome evidence.

3.3 HARP Stakeholder Remote Patient Monitoring Technologies Workshop

3.3.1 Introduction

In considering the relevance of technology for the distance monitoring of patients with COPD and CHF, the HARP Technology Working Party conducted a half-day workshop on remote monitoring technologies.

3.3.2 Objectives

The objectives of this workshop were:

- to identify available and emerging RPM technologies
- to identify opportunities for the utilisation of RPM technologies within HARP projects
- to identify and address issues relating to the implementation of RPM technologies.

3.3.3 Outcomes

In the workshop, the consultants briefed participants on the results of the survey that was undertaken and reported on the status of RPM technology as reflected by the telemedicine literature.

The workshop was then used as a forum to:

- gather from participants, knowledge and experience in the use of RPM technology in disease management
- obtain input in relation to establishing immediate and future RPM technology requirements
- identify issues that need to be dealt with in relation to the use of RPM technology
- foster sharing of information between participants to encourage the use of RPM technologies for patients with COPD and CHF.

These outcomes have been used as a basis for much of this report.

3.4 Follow-up interviews

Follow-up contact was undertaken with a number of interested parties including:

- Mr Laurie Wilson, CSIRO e-Health project
- Ms Jill Clarke, WA Health Telehealth Development Unit
- Debora Oong, Manager IT and Telehealth, NSW Health
- Kaylene Fiddes, Project Manager, Victorian Centre for Ambulatory Care Innovation
- Nikki Collins, Statewide telehealth services – QIEP, Queensland Health
- Dr Branko Cesnik, Centre for Medical Informatics, Monash University.

These interviews indicated that there is very little experience in RPM disease management projects in Australia, and that most States have concentrated on, and continue to concentrate on, videoconferencing telemedicine projects.

Jill Clark from WA Health reported that a three-month trial was established in January 2003 to monitor blood sugar in home-based, rural diabetic patients using the mobile telephone network.

The GP-managed Home Telecare project, described by Professor Celler at the Disease Management Conference, is a limited trial that aims to validate the technology in the context of CHF and COPD patients in Sydney and Wagga Wagga.

The study and its outcomes are documented in a detailed final report [94], which includes a COPD and CHF case study. The authors have indicated that cost benefit analysis is beyond the scope of the project and would require data from a larger clinical trial.

3.5 Available technologies

3.5.1 Introduction

A wide range of technologies are identified in the TIE database [3], the TIS database [4], the two key international telemedicine journals and Web pages of many commercial companies. Twenty-eight RPM equipment suppliers were identified from these sources. An analysis and contact details of these technologies is provided in Appendix B. These commercial RPM equipment systems record and transmit a wide range of physiological parameters including:

- EEG
- Holter EEG
- spirometer
- electronic stethoscope
- weight
- blood pressure
- heart rate
- oximetry
- temperature
- glucometer.

Most systems have software for recording data and plotting trends, all have telecommunications capability, and all are Federal Drug Administration (FDA) and most are European Union (EU) certified.

A summary of generic RPM systems is provided in section 3.3 .

3.5.2 Plain old telephone system (POTS)

Many home-based disease management programs in the literature report the use of conventional telephone teleconsultations as a means of acquiring data to plot trends in parameters such as blood pressure and weight. This is often undertaken within a set protocol that includes patient education as an additional aim. In more sophisticated programs a computer controlled telephone replaces the clinician and answers are automatically logged.

3.5.3 Individual diagnostic tests

A number of RPM systems can be configured to record and transmit a single physiological parameter, such as blood pressure, blood glucose or spirometer.

Such systems are reported in the home-based management of hypertension, diabetes and asthma patients.

Some video telephone systems make provision for the transmission of physiological parameters but do not usually suggest a particular vendor or guarantee that the combined systems are compatible or that software at the receiving end is available.

Some of the equipment provided by the vendors under this category is listed below as examples:

- Aerotel Medical Systems:

  BP-Tel TM (Transtelephonic Blood Pressure Meter); Weight-TelTM (Transtelephonic Weight Scale); Gluco-TelTM (Transtelephonic Blood Glucose Level Meter); Oxi-TelTM (Transtelephonic Blood Oxygen Saturation Level Meter [SpO2]); Flow-TelTM (Transtelephonic Respiratory Flow Values Meter); HeartOneTM Transtelephonic ECG Meter.

- SHL Telemedicine:

  TelePress (Blood Pressure Meter); TeleBreather (Respiratory Meter); TelePulse Oxymeter; TeleWeightTM; CardioPocket CB-250 (ECG Transmitter); Cadiobeeper CB series.

3.5.4 Computer-based integrated RPM

A number of systems use personal computer based measurement systems that instruct the patient, control measurements and transmit signals. These systems require a dedicated personal computer in the patient's home. There is a requirement for patient training and ongoing systems support.

Some of the equipment provided by the vendors under this category is listed below as examples:

- Brentwood: IQmarkTM
- QRS Diagnosis: QRS Cards
- AMD Telemedicine: Monitoring stations (series).

3.5.5 Home-based vital signs monitoring

Home-based vital signs monitoring equipment provides a simple to use method for measuring the physiological parameters of chronically ill patients on a daily basis. The system usually consists of a monitor in the patient's house that collects and transmits data, and a central computer that receives data, stores it and presents it to clinical personnel for monitoring and trending. Integrated systems are available with reporting and data management software. Some of the equipment provided by the vendors under this category is listed below as examples:

- American Telecare: SLX/XR Patient Station
- Homemed: HomeMed Monitor

- Neptec: CareCompanion
- March Networks
- Aerotel Medical Systems: Tele-CliniQTM
- SHL Telemedicine Ltd: Home Care Center IV
- CyberCare: EHC Stations (Electronic House Call)
- Cybernet Medical: MeStarTM.

3.5.6 Home automated monitoring device

A home automated monitoring device is a home messaging device that beeps each morning to prompt the patient to respond to 6–8 questions that appear on the device's screen one at a time. The patient must answer each question by pressing one of four buttons. Depending on the answers, the care coordinator sees a light flashing in green (everything is fine), yellow (a change of health status needing to be monitored) or red (telephone the patient now).

The system is supported with trending, reporting and data management software. Examples include:

- Health Hero: The health buddy
- American Telecare: Monitoring Station
- Homemed: HomeMed Monitor.

3.5.7 Video Phone Systems

Video phone systems permit automatic data transmission, which allows the care giver to receive instant information from vital signs equipment, electronic stethoscopes, ECGs and other devices while talking to and seeing the patient, and viewing their records on an attached personal computer. Care station videos are ideal for elderly and chronically ill patients, as well as patients living in remote areas who cannot be transported easily to a medical facility. Some of the equipment provided by the vendors under this category is listed below as examples:

- American telecare: SLX/XR Patient Station
- Neptec : CareCompanion
- CyberCare: EHC Stations (Electronic House Call).

4 Potential remote patient monitoring models of care

4.1 Introduction

In the consideration of RPM technologies and their possible application to HARP projects, it is necessary to consider how RPM technology will fit within existing models of care. This section provides some example models of care where RPM may add value.

Consultation with COPD and CHF care providers has indicated that the introduction of RPM technology is most likely to be successful and effective if a planning process is undertaken that integrates the monitoring process with existing care models. Some consideration of models of care is therefore appropriate (see Chapter 5). Two care models are considered below, one of which is a hospital outreach model and the second is a GP-based model.

4.1.1 Disease management models of care

Disease management programs focus on implementing evidence-based practice and better coordinated care for people with chronic illness, such as COPD and CHF. These programs are structured around the implementation of evidence-based clinical practice guidelines across the continuum of care from the acute hospital through to the community services, including GPs, district nursing, allied health and ambulance services. There are a number of models of care for the implementation of disease management programs and, for the purposes of this report, a hospital outreach and a general practice model will be explored.

The key success factors identified as important to effective disease management programs include:

- use of explicit plans and protocols
- reorganisation of practice systems and provider roles (move away from an episodic approach to managing acute illnesses to a holistic approach across the continuum of care)
- systematic attention to the information and behavioural needs of patients
- ready access to necessary expertise
- improved self-management support
- extended periods of follow-up
- control over implementation of individual care plans
- supportive information systems [179].

The area of 'extended periods of follow up' is where the role of remote monitoring may be effective. Participants of disease management programs exhibit chronic or recurring symptoms and it can be hypothesised that by monitoring these symptoms closely it is possible to anticipate deterioration in the person's condition and intervene prior to the requirement for rehospitalisation. Additionally, the process of monitoring clinical parameters may provide positive feedback that encourages the

client to adhere to the proposed treatment regime or, alternatively, improved patient education and self-management may be a by-product of introducing the remote monitoring system.

4.1.1.1 Hospital outreach–nurse home visits

Presentation to hospital represents an opportunity to improve management of chronic illness on a disease-specific basis. Patients presenting to hospital with a chronic illness, such as COPD or CHF, can be linked into a disease management program involving:

- input from a multidisciplinary team, including the appropriate medical specialist (cardiologist/respiratory physician)
- review of their current treatment regime in line with best practice principles
- patient education and self-management guidelines
- development of an individualised care plan that spans the continuum of care
- involvement of GPs in case conferencing and care planning using the Medical Benefits Scheme Enhanced Primary Care (EPC) items
- liaison with family members, GPs and, if appropriate, community agencies to facilitate the essential elements of the discharge plan
- access to appropriate cardiac/pulmonary rehabilitation programs
- the nurse continues to liaise with the GP, medical specialist and other community agencies regarding the ongoing management plan
- ongoing monitoring in the home to undertake assessment including medication adherence, and to reinforce self-care guidelines, by a nurse or member of the multidisciplinary team who specialises in COPD/CHF. Ongoing monitoring may be in the form of home visits, telephone calls or by using one of the remote monitoring technologies or a combination of these. (Using a remote monitoring technology may enable more patients to be managed within the disease management program, as less time is spent travelling to clients' homes).

4.1.1.2 General practitioner practice

The hospital outreach model could also be adapted to a large general practice setting that employs a practice nurse. In this scenario, the general practice could set up a shared care arrangement with a medical specialist (cardiologist/respiratory physician). Ideally, the GPs and the practice nurse have had specific education related to the management of COPD/CHF, this could occur as part of the shared care arrangement.

- Patients are recruited to the Disease Management Program from within the general practice or by referral from the medical specialist.
- An individualised care plan is developed that incorporates regular reviews by the medical specialist dependent upon the severity and stability of the patient's illness (eg. 3–12 monthly).

- The practice nurse, in collaboration with the GP, provides patient education and self-management guidelines.
- The GP uses the EPC items as required for care planning and case conferencing.
- The practice nurse liaises with family members and, if appropriate, community agencies, as required.
- Access is provided to appropriate cardiac/pulmonary rehabilitation programs.
- The practice nurse provides ongoing monitoring in the home environment to undertake assessment, including medication adherence, and to reinforce self-care guidelines. Ongoing monitoring may be in the form of home visits, telephone calls or by using one of the remote monitoring technologies, or a combination of these.
- The practice nurse notifies the GP of any concerns regarding the patient's condition or treatment plan.
- The GP liaises with the medical specialist as required.

4.2 Further discussion

Although there is an absence of evidence confirming the value of monitoring patients at home as a component of a disease management model of care, the above models of care suggest that monitoring a patient's medical condition or compliance to a care regime can easily be integrated into a model of care. If this is to be embarked upon, the technology related aspects need to be integrated into the existing model of care. Data gathered will inform the decision making process and need to be integrated into the patient's medical record.

5 Implementation of a remote patient monitoring model

5.1 Introduction

As pointed out in section 3.3, there is a wide and increasing range of commercially available RPM technology on the market. Section 2.2 indicates that much of this technology is the subject of pilot studies and evaluation trials and suggests that there is not yet a body of evidence to establish the value of RPM in the context of disease management in general and CHF and COPD patient management in particular.

In the case of HARP projects in particular, and disease management in general, there are a number of care models under consideration (see section 4.1.1). These models of care are themselves the subject of evaluation.

This suggests a need to match technology to a particular model of care making sure that at the project planning stage the establishment of project requirements includes the establishment of technology requirements. Given that there is a significant choice of technologies, project planners should become familiar with each of these technologies and their capabilities and limitations. This report will assist project participants to identify the available technologies and sources (see section 3.3). New RPM technologies will, however, emerge as frequently as the enabling IT&T technologies, and the cost of these technologies will reduce in tandem with emerging IT&T technologies. Health professionals will need to continue to monitor the emergence of new RPM technologies.

A number of reports suggest the ongoing need to raise the level of technology literacy amongst health professionals, including clinicians [75, 180]. As with other areas of medical evidence, evidence concerning RPM (and other medical technologies) can be found in the literature identified in this report and in library databases.

Unfortunately, to our knowledge, no product comparison for RPM technology evaluation has yet been undertaken. Such product comparisons are frequently used to help select conventional medical equipment (reference: http://www.ecri.org/hpcs).

In the following sub-sections, a model is mapped out for the implementation of RPM and a number of key issues that need to be considered in line with implementation are identified.

5.2 Common features of a model for RPM in disease management

The literature suggests there are a number of common features relating to how RPM technology is used within disease management programs. These features differ from features within models of care focused on diagnosis or immediate intervention.

An example of diagnostic RPM is the use of a telecommunications connected Holter monitor for the measurement of ECG, and the subsequent diagnosis of cardiac disorders [29].

An example of immediate intervention RPM is home-based monitoring of early release post-acute cardiac patients who may be monitored remotely by a cardiac care department that establishes a protocol of immediate intervention [34] (in pilot stage).

In the case of disease management, the primary objective is usually long-term home care rather than diagnosis or immediate intervention [128, 140, 161, 164]. This determines the following common features for RPM in home care disease management projects:

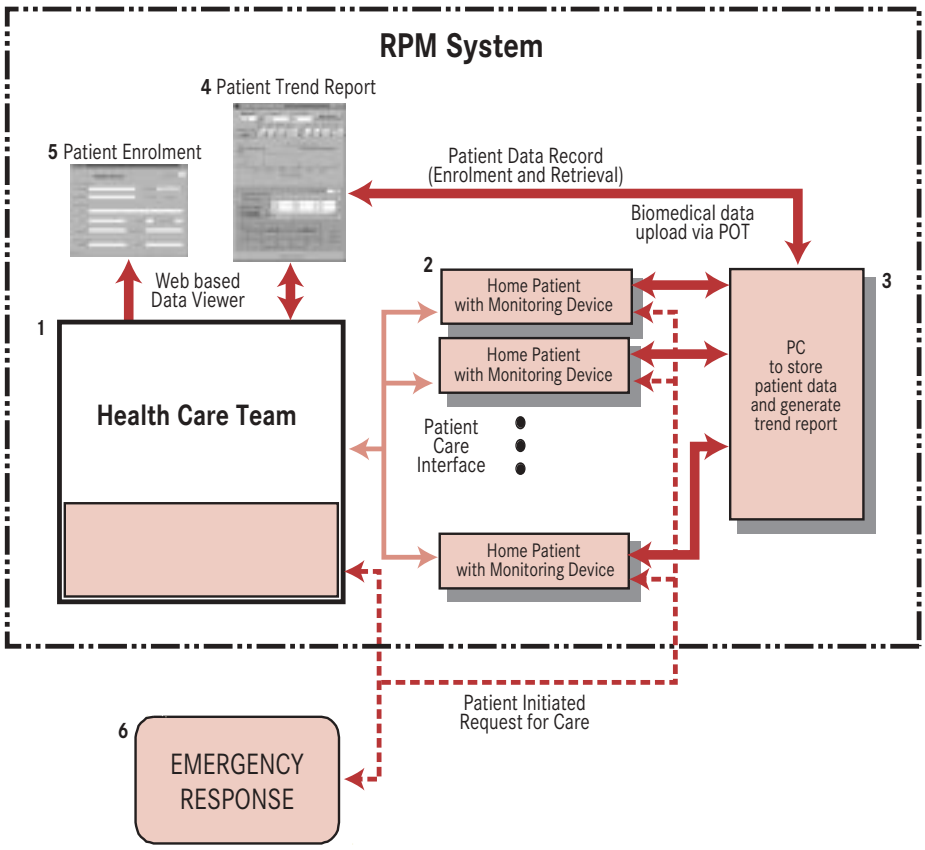
1. regular monitoring rather than continuous monitoring of patients
2. generally use the POTS rather than broadband, higher performance telephone system
3. long-term trend plotting and the need for appropriate software
4. long-term technology allocation with associated cost
5. training of patients in technology use
6. training of clinicians in technology use
7. technology maintenance and support
8. RPM data used as additional component of patient record to improve the quality of care
9. response to abnormal monitoring parameters is in line with usual protocols of the health care organisation
10. strong patient education component and patient involvement in their care
11. equipment designed for patient use.

5.3 Implementation model

Figure 5.1 is a generic implementation model for introducing patient monitoring in the context of a disease management program. Such a model may be useful in considering the feasibility of introducing RPM to a disease management program, identifying the requirements for such a program or designing a monitoring system. It identifies technology requirements, shows information flows and identifies stakeholders.

The model is generic as it does not identify a model of care, a particular monitoring technology or a disease. The model can, however, be modified to represent a particular project where these parameters are specified.

Figure 5.1: Generic implementation model for RPM in a disease management program.



5.3.1 Description of model

1. A number of patients are managed at home (Box 2) and supported by the appropriate health care professionals within a specific model of care (Box 1). The health care team (Box 1) will include of a number of stakeholders that could consist of a GP, a medical specialist, nurse, a care coordinator or allied health. The composition of the health care team will be determined by the model of care as discussed in Chapter 4.
2. These stakeholders may be from different organisations across different sectors of the health care system. Therefore, it is important to have clearly defined roles and responsibilities for each member of the team and clearly defined communication processes, including data flows.
3. Each patient has a home monitoring device, which can be any one of the generic RPM technologies identified in section 3.3. This device can be a simple conventional telephone or a more complex video telephone with a range of measured physiological parameters.

4. A member of the health care team initiates a data request from each of the home care patients in turn.
5. Data from the individual RPM units is transferred by a telephone line to a computer, which can store a number of patient records and produce trend data.
6. Patient data records are initiated by a member of the health care team and reports on individual patients can be accessed by the team using a Web-based data viewer.

   NB. The patient data record may be stored separately to the actual patient medical record, particularly at this point in time due to the limited use of shared electronic records. This raises the issue of split records, where a clinician may have access to the patient's medical record but not to the patient's RPM data record, which has the potential to lead to mistreatment. Guidelines need to be developed to cover this issue. Consideration needs to be given to integration of patient records and the data interface and who has access to what.
7. Although the RPM data will not normally trigger an immediate intervention, emergency situations that may develop while the patient is with the home care program are managed in accordance with established health service protocols.
8. GP requests for care may be an option for immediate intervention as discussed in point 7 above. This would need to be clearly documented in the home care protocol.
9. Data from RPM supplements other data gathered by the health care team and is used as a contributing element of patient review.

5.4 Conclusion

The model presented above aims to assist consideration of:

- the feasibility of introducing RPM to a disease management program
- identifying the requirements for such a program
- designing a monitoring system.

It identifies technology requirements, shows information flows and identifies stakeholders.

To take this model further it is necessary to specify a particular disease and model of care, and then identify monitoring parameters and technology, stakeholders and their roles and information requirements, details of the operational protocol, and telecommunications requirements.

6 Best practice principles and recommendations

6.1 Best practice principles

Although the literature dealing with RPM in the context of disease management is extensive, there is no established best practice. However a number of principles have emerged from evaluation studies and pilot studies.

This section identifies best practice principles for the planning and implementation of RPM technologies in the context of disease management, as reflected in the literature. Although these principles may need to be adapted to suit a particular HARP project, many of them are generic. They have been reported in published papers on general applications of telemedicine, in a number of papers dealing with RPM as it relates to a range of different disease management projects, and in conference proceedings and journal editorials.

Much of the opinion on best practice is recent and relates to second generation telemedicine technology including home monitoring technology. Some of these principles were confirmed or raised at the workshop and the Technology Working Party meetings.

These principles frequently interrelate with each other but, for the purpose of providing a useful basis for developing recommendations, they are grouped under the following headings:

1. Project planning
2. Matching technology to projects
3. Limiting the range of technology
4. Project management
5. Information sharing
6. Technology support
7. Change management issues
8. Technology issues
9. Project evaluation
10. Funding and reimbursement.

6.1.1 Project planning

The implementation of technology needs to be carefully planned as an integral part of project planning. Planning steps are:

- Clear definition of the problem and objectives.
- Clinical process designed to achieve the objectives, with the use of technology as only one part of the many necessary components.
- Stakeholder support for the proposed process.
- Ensure that the use of technology does not have a negative impact on patient care.

- Determine how you will evaluate whether you have solved (or are solving) the problem identified. Include adequate resources for evaluation within the project plan. Evaluation should include efficacy, cost-effectiveness and negative outcomes.

  The following points also relate to the need for a planning process:

  1. Project requirements should be initially determined, and then technology requirements should be determined to support these project requirements.

  2. Project requirements include clear objectives, a supportive culture, simplicity, an evaluation process and cost-effectiveness monitoring.

  3. The importance of 'adding' these technologies to projects that already have an established and effective strategy, such as disease management or case management, rather than creating new systems and infrastructure just for the technology alone.

  4. Technology itself should not be the focus. Technology should be seen as an extension of the overarching health service, otherwise it will not be properly adopted and it will become an orphan outside existing systems.

  5. Cost factors should be identified within projects.

  6. Technology trials should extend long enough for the evaluation of outcomes to be determined on a proper statistical basis.

  7. Patient records, from remotely collected data or documented teleconsultations, should be considered equivalent to any other patient data or documentation and managed appropriately.

  8. Legal aspects should be carefully considered within the context of a project.

  9. Tight inclusion and exclusion criteria are needed for patients trialing such technologies.

  10. Determining whether the technology will be used to augment care within business hours or for 24-hour monitoring (and, if so, establishing appropriate support networks for after-hours advice).

  11. Developing an appropriate evaluation methodology, for example, comparing 'normal care' with 'normal care plus technology'.

  12. Ascertaining how the use of these technologies will interface with general practice.

  13. The importance of communication with and involvement of all stakeholders in a project, including all providers, and the patient and the carer.

6.1.2 Matching technology to projects

There is not a single technology that fits all patient situations and there are different levels of technology. This means that projects should establish their technology requirements and match these requirements to available technology.

6.1.3 Limiting the range of technology

Given the large and increasing number of RPM equipment suppliers and the diverse range of available RPM technology, there is a risk of projects collectively adopting an excessive number of different RPM technologies. It is likely to be preferable to limit the number of different technologies at this stage so that the pooled experience and evaluation data can be more effectively shared. The range of generic technologies reported in the literature and available commercially are briefly described in section 3.3. A comparative evaluation of this equipment would be useful in identifying a limited range of equipment systems for HARP projects.

The US Department of Veterans Affairs, in their large VISN8 clinical demonstration program taking place in Florida [181-183], has selected a limited number of technologies for evaluation. This program aims to service chronically ill patients at high risk of re-hospitalisation, including the frail elderly, medically complex and mentally ill. It has been operational since April 2000 and covers 1,200 patients. With such a broad coverage of patients and associated needs, their approach has been to match the technology to the patient. Accordingly, they offer five different technologies for selection for new patients to use in their home. These technologies are telemonitoring (using a dedicated workstation with attached medical peripherals and incorporating videoconferencing), videophones, in-home messaging devices, wound care cameras, and computers with Internet chat rooms. The technology is selected according to complexity of illness, degree of monitoring required and patient ability, and is reviewed after 90 days to ensure patient compliance and satisfaction. To minimise the number of different technologies in use, only one commercial supplier has been selected for each of the five levels of technology.

6.1.4 Project management

The introduction of new technology to either a new or existing project requires project management and a project manager. The project manager will need to establish technology requirements, select technology vendors and arrange technology acquisition and support.

There are a number of key tasks and considerations that need to be undertaken by the project manager including:

- integrating the RPM technology into an existing model of care
- developing a project plan that includes milestones and evaluation
- collaborating with key stakeholders
- acquiring the RPM technologies, which may need to be acquired from more than one vendor
- the requirement for patient data records and trend plotting software in association with the RPM technology
- requirement for staff and patient training regarding RPM technology
- establishing uniform protocols for the operational phase of the project.

6.1.5 Information sharing

1. Projects should use a protocol that enables data sharing of outcomes and evaluation, to allow project outcomes to be collated and benchmarked. For example, if video consultations are used, standard information about these consultations should be collected.

2. There is a need to raise awareness of what technology is available and the experience of others at project, program, state, national and international levels.

3. To promote sharing of experience, there should be a repository of RPM projects.

4. Lessons learned and best practice from many grant funded programs are a rich source of information, therefore interstate and overseas reports should be monitored.

6.1.6 Technology support

As RPM technology is usually located in a patient's home it is not under the control or supervision of either a health professional or a biomedical engineer. Because the equipment is being used to make important medical decisions relating to the patient's care it is important that every RPM equipment item is subject to an in-service testing and maintenance program. Technical support is therefore essential.

6.1.7 Change management issues

In addition to technology acquisition, change management issues need to be dealt with prior to and during the introduction of an RPM system. These issues essentially relate to the changing role of members of the health care team and changes to the role of patients, particularly in relation to their interaction with, and acceptance of, technology. The design or selection of the patient machine interface is important in relation to this issue.

New roles may include the role of clinician in relation to data ownership and management, remote patient communication and patient technology training. Considerable time may be required to assist staff in familiarising themselves with the equipment. This has been reported as posing a barrier to its use [75].

6.1.8 Technology issues

1. Equipment procurement may be difficult as no single supplier may be able to meet the project's full requirements. It may be necessary to identify multiple vendors and undertake negotiations with each of them separately.

2. It is probably preferable to use proprietary technology as it is more likely to be supported and improved in the long term as technology changes.

3. Technology (including equipment and systems of equipment) should be provided with adequate technical support over the life of the project.

4. Technology (including equipment and systems of equipment) should comply with medical equipment safety standards.

5. Technology (including equipment and systems of equipment) should be acceptance tested and subject to a regular in-service maintenance program, like all medical equipment.

6. Remote monitoring technologies should be reliable and as a matter of patient safety these characteristics should be able to be demonstrated.

6.1.9 Project evaluation

Project evaluation needs to be established during the planning phase of the project. One approach used for testing the effectiveness of combining different technologies with care coordination, compares the outcomes achieved using normal care to the outcomes achieved with a combination of normal care and technology. This approach can be used irrespective of the technology chosen, although aggregating data must be undertaken cautiously as technology can have both positive and negative effects on outcomes.

A number of evaluation criteria were identified in the literature and were discussed during the RPM technologies workshop. These include an evaluation of effectiveness, efficiency, quality of care, quality of life, safety, cost benefits, patient acceptance and patient satisfaction.

6.1.10 Funding and reimbursement

Funding and reimbursement is an issue that is discussed in a significant number of reports on telemedicine and is frequently cited as an issue that needs to be addressed. Because this report is essentially concerned with the use of technology in disease management programs, the issue of funding and reimbursement of service provision will not be dealt with in detail. However, consideration needs to be given to cost. The cost related issue that will be raised is the cost associated with acquiring, supporting and replacing RPM technology. The cost of ownership should be considered in relation to the broader funding and reimbursement issue.

6.2 RPM implementation checklist

In line with the RPM implementation model introduced in section 5.3, the following checklist has been developed to guide health workers intending to submit proposals for the introduction of RPM technology into disease management programs.

RPM Implementation Model Checklist

Item	Requirements
Technology cost	An estimate of cost associated with technology ownership and maintenance should be detailed within proposal.
Data management	Data flow, data ownership, data access, data security and data safety need to be dealt with in systems design and within operational protocol.
Health care team	Proposal should indicate the key stakeholders and that the team supports the introduction of RPM technology. Their roles need to be defined in relation to technology use, data ownership, data access, etc.
Legal issues	Program specific issues should be documented in the proposal.
RPM operational protocol	Required to define health care team roles, patient involvement, information flows and data management. This protocol should augment the usual care.
Patient data storage	System design consideration needs to be given to the data storage and trend analysis reporting software.
Patient initiated contacts	Dealt with in protocols for operation of program.
Patient interface	System design consideration needs to be given to the patient/technology interface. This interface may need to be designed to match a patient's disease specific disabilities.
Project evaluation	Projects need to be evaluated by comparing normal care with normal care plus technology. Evaluation should include patient outcomes, quality of care, quality of life, cost and patient acceptance.
Project requirements	Should justify the need for RPM technology in terms of improving clinical outcomes, better use of resources and greater patient involvement in care.
Risk analysis	Proposals should include an analysis of key risk factors associated with the introduction of RPM technology.
Scope of project	Determine human and technology resources required.
Service quality	Proposals should deal with the impact of RPM on service quality. The impact of equipment reliability should be considered in relation to patient safety and service quality.
Technology requirements	Required to match to available technology.
Technology support	Needs to be factored into program and costs identified.

6.3 Recommendations

A number of recommendations are proposed.

1. RPM should be considered in relation to existing projects for the management of chronic disease in situations where the introduction of technology is likely to improve the clinical outcomes, make better use of available resources, and improve patient involvement in their care. In proposals for the use of RPM technology, the perceived benefits of using RPM technology should be specified in relation to these terms.

2. It is strongly recommended that RPM technology be piloted with established COPD and CHF projects so that this experience can be used to inform broader implementation in the future. Technology requirements should therefore be written to support disease management project requirements.

3. The implementation model outlined in section 5.3 be used as a template to ensure comprehensive consideration of the relevant stakeholders, information flow and technology issues. An RPM Implementation Checklist is provided in section 6.2 to assist this process.

4. That HARP disease management projects embarking on the introduction of RPM engage the required technical support for the establishment of technology requirements, for undertaking effective:

- system design
- selection of technology
- implementation.

5. That HARP disease management projects embarking on the introduction of RPM take into consideration the telecommunications infrastructure requirements for effective communication. (It is noted that the 'Health Tel network' available for both acute and primary care applications would provide the bandwidth and speed needed for the more advanced RPM applications.)

6. That all disease management projects that introduce RPM technology undertake to evaluate the proposed project in relation to patient outcomes; quality of care; cost-effectiveness; patient involvement in disease management; and better use of available resources.

7. That HARP project participants continue to monitor RPM technology developments and the emergence of evidence relating to the evaluation of new technology, and share learnings to raise the knowledge base statewide and amongst HARP project participants.

8. That an evaluation of commercially available technology be undertaken by an independent evaluator to establish its technical, clinical and safety characteristics in the contexts of the management of CHF and COPD patients. The purpose of this evaluation is to assist clinicians in the selection of appropriate and safe commercially available RPM technology.

Appendix A: Literature search methodology

Sources and approach

Three major sources have been used for the literature review:

1. Databases of journal articles, searched using common search terms.

2. Key international journals, comprehensively reviewed for relevant articles.

3. Internet search for commercially available equipment and service providers for the home-monitoring of COPD and CHF patients.

Journal database search

Databases searched were Current Contents, Medline and IEEExplore. Current Contents and Medline provided good coverage of medical/clinical literature, while IEEE provided good coverage of engineering work.

Published journal articles and conference presentations have been searched from 1995 onwards, as we have found little relevant material (for RPM) prior to this date.

Search terms used for the journal database searches were:

1. CHF: <CHF> or <congestive heart failure> or <heart failure>

2. COPD: <COPD> or <chronic obstructive pulmonary disease> or <COAD> or <chronic obstructive airway disease> or <emphysema> or <chronic bronchitis>

3. Telemedicine: <telemedicine> or <ehealth> or <e-health> or <hospital in the home> or <HITH> or <HIH> or <telematics> or <remote patient monitoring>

4. 1 and 3 (ie. CHF and Telemedicine)

5. 2 and 3 (ie. COPD and Telemedicine)

For the three databases searched, the number of citations reported is shown in Table 1. The abstracts of these articles were reviewed and articles were sought where relevant content was found.

Since the number of articles found in the IEEE journals was very low using these search terms, another search using the keywords <Telemedicine> (compound term as defined above) and <patient monitoring> was conducted for these journals. The resulting number of citations is shown in Table 2.

Table 1: Number of citations returned for each (compound) search term, for the three journal databases searched.

Database (search date)	CHF (citations)	COPD (citations)	Telemedicine (citations)	CHF and Telemedicine (citations)	COPD and Telemedicine (citations)
Current Contents (11-Dec-2002)	27,005	9,686	2,220	20	10
Medline (11-Dec-2002)	39,113	25,127	5,004	35	16
IEEExplore (11-Dec-2002)	195	45	1,144	1	0

Table 2: Number of citations returned for non-disease specific telemedicine patient monitoring applications in biomedical engineering journals.

Database (search date)	Telemedicine (citations)	Patient Monitoring (citations)	Telemedicine and Patient Monitoring (citations)
IEEExplore (20-Dec-2002)	1,069	1,220	96

Key international journals

Two key international journals were comprehensively reviewed:

1. Journal of Telemedicine and Telecare, published by the Royal Society of Medicine, ISSN 1357-633X.
2. Telemedicine Journal and e-Health, published by Mary Ann Liebert, Inc., ISSN 1530-5627, and is the journal of the American Telemedicine Association. This journal was previously published as Telemedicine Journal, ISSN 1078-3024 until June 2000. This journal also dedicates one issue each year to the listing of abstracts of presentations and posters from the association's annual meeting, which is a major conference for the telemedicine industry.

A total of 100 articles were sourced from these journals. Articles were categorised by content into one of eight themes:

a) Articles specifically dealing with remote patient monitoring of COPD patients. (6 articles)

b) Articles specifically dealing with remote patient monitoring of CHF patients. (6 articles)

c) Articles specifically dealing with remote patient monitoring of other chronic diseases, or dealing with general issues of remote patient monitoring. *(18 articles)*

d) Articles dealing with the design, implementation or evaluation of telemedicine projects (including remote patient monitoring). *(38 articles)*

e) Articles dealing with the evidence base for telemedicine application. *(9 articles)*

f) Articles dealing with ethics and legal issues of remote patient monitoring. *(7 articles)*

g) Articles dealing with Australian telemedicine projects, in all areas of telemedicine application not necessarily limiting to remote patient monitoring. *(9 articles)*

h) Articles dealing with human factors (organisational), editorials and general telemedicine issues. *(7 articles)*

Other major journals should also be searched in this same manner. Table 3 below shows a list of major journals that would be relevant. The first two journals listed are those reported above.

Table 3: Major journals relevant for reports of technology used in home-monitoring of chronic illness of CHF and COPD patients.

No.	Journal Name	ISSN	Publisher	Dates Published	Indexed by
Telemedicine / Telematics / Informatics					
1	Journal of Telemedicine and Telecare	1357-633X	Royal Society of Medicine Press	1996+	Medline, CC
2	Telemedicine Journal and e-Health	1530-5627	Mary Ann Liebert, Inc.	1999+	Medline, CC
3	International Journal of Medical Informatics	1386-5056	Elsevier Science	1997+	Medline, CC
4	Journal of the American Medical Informatics Association (JAMIA)	1067-5027	Hanley & Belfus	1993+	Medline, CC, CINAHL
5	Medical Informatics and the Internet in Medicine	1463-9238	Taylor & Francis Health Sciences	1999+	Medline, CC
6	Health Informatics Journal	1460-4582	Sage Publications	2000+	CINAHL
7	Health Informatics Europe	0969-0719	BJHC Ltd.	1993-1995	CINAHL
8	Informatics in Primary Care	1476-0320	Radcliffe Medical Press	2002+	
9	Informatics in Healthcare, Australia	1323-4382		May 1992+	CINAHL
10	Healthcare Informatics (Magazine)				
11	Telehealth Magazine (Telemedicine & Telehealth Networks)	1522-354X	Miller Freeman, Inc.	1995+	
12	Telematics and Informatics	0736-5853	Elsevier Science	1995+	
Disease Management					
13	Disease Management	1093-507X	Mary Ann Liebert, Inc.	2001+	CINAHL
14	Disease Management & Health Outcomes	1173-8790	Adis International, NZ	1997+	CC, CINAHL
15	Disease Management and Clinical Outcomes	1088-3371	Elsevier Science	1997 - 1998	CC

No.	Journal Name	ISSN	Publisher	Dates Published	Indexed by
CHF					
16	Congestive Heart Failure	1527-5299	Heart Failure Society of America	1997+	Medline
17	European Journal of Heart Failure	1388-9842	European Society of Cardiology, Elsevier Science	1999+	Medline, CC
18	Journal of Congestive Heart Failure and Circulatory Support	1468-3768	Martin Dunitz, part of Taylor & Francis Health Sciences (ISIS Medical Media)	2001+	
COPD					
19	Respiratory Medicine	0954-6111	Elsevier Science		Medline, CC, CINAHL
20	American Journal of Respiratory Medicine	1175-6365	Adis International, NZ	2002+	
21	American Journal of Respiratory Critical Care Medicine	1073-449X			CC, CINAHL
22	European Respiratory Journal	0903-1936	European Respiratory Society	1999+	Medline, CC

Internet search for commercial equipment and service providers

Company web pages and research project web pages were identified using standard www search tools (eg. Google). Terms used included Home Monitoring and Disease Management. Commercial equipment manufacturers and service providers identified through this process have been listed in Appendix B.

Appendix B: Spreadsheet of available technologies

	Equipment Provider	ECG	Holter	Spiro	Steth	Wt	BP	HR	Oxi	Temp	Glu	S/W	Com	A/V	Cert	Web address
1	Aerotel Medical System	X		*		X	X	X	*		*	X	X		X	www.aerotel.com
2	AMD Telemedicine	X		X	X	X	X	X	X	X		X	X	X	X	www.amdtelemedicine.com
3	American Telecare	X			X	X			X	X	X	X	X	X	X	www.americantelecare.com
4	Brentwood	X	X	X		X	X	X	X	X		X	X		X	www.brentwoodmed.com
5	Cardio Control	X		X				X				X	X		X	www.cardiocontrol.com
6	CardioNet	X										X	X		X	www.cardionet.com
7	CardGuard	X		X				X			*	X	X		X	www.cardguard.com
8	Compumedics (AU)	X	X					X	X			X	X	X	X	www.compumedics.com.au\
9	CyberCare Technology	X			X	X	X	X	X	X	X	X	X	X	X	www.cyber-care.net
10	Cybernet Medical	*		X		X	X	X	X		*	X	X		X	www.cybernetmedical.com
11	GE Medical	X	X				X	X	X			X	X		X	www.gemedicalsystems.com
12	HealthFrontier	X										X	X		X	www.healthfrontier.com
13	Health Hero											X	X		X	www.healthhero.com
14	HomeMed			*		X	X	X	X	X	*	X	X		X	www.hommed.com
15	Jaeger	X		X					X	X		X	X		X	www.viasyshealthcare.com
16	March Networks				X	X	X	X	X	X	*	X	X	X	X	www.marchnetworks.com
17	Micromedical (AU)	X										X			X	www.ventracor.com
18	Mini Mitter							X		X		X			X	www.minimitter.com
19	Neptec	*		X	X	X	X		X		X	X	X	X	X	www.neptec.com
20	Pacerart	X										X	X		X	www.paceart.com
21	Phillips Medical	X				X	X	X	X			X	X		X	www.medical.philips.com/main
22	Pulse Biomedical	X	X				X					X	X		X	www.qrscard.com/products.htm
23	QRS Diagnosis	X		X					X			X			X	www.qrsdiagnostic.com
24	RAYTEL Cardiac Services	X	X				X	X				X	X		X	www.raytel.com
25	SHL Telemedicine	X		X		X	X	X	X			X	X		X	www.shahal.co.il
26	Tunstall Group	X		X			X	X	X	X		X	X		X	www.tunstall.co.uk
27	VivoMetrics (LifeShirt)	X		X				X	X			X			X	www.vivometrics.com
28	Welch Allyn	X					X	X	X	X		X	X		X	www.welchallyn.com

* - Under development or pending approval

Shorthand : A/V - Audio Visual link; BP - Blood Pressure; Com - Communication Link; Glu - Glucometer; HR- Heart Rate; Oxi- Oximeter; Sprio - Spirometer; Steth - Electronic Stethoscope; Temp - Temperature

Date: 29th Dec 2002

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