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Guardian Angel Project
Final Report

Medical Scenarios for System Test and Evaluation

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By

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Executive Summary

Guardian Angel is a demonstration project concerned with technology for patient monitoring, remote communication to a central server, presentation of data within distributed environments, imaging and diagnostics. The aim of the work reported here was to develop scenarios to envision how the Guardian Angel technology could be used to support work processes in healthcare. Scenarios are descriptions of a users' interaction with a system that contain enough context and detail to visualise how a system might work. The report considers first the context of the healthcare system then briefly reviews previous applications of technology in healthcare to identify what sectors of the healthcare system might be receptive to new technology. Scenario based design is then discussed and healthcare tasks are categorised to provide a basis for the development of healthcare scenarios for Guardian Angel. These are described in the next sections before conclusions and recommendations for future work are made.

The healthcare system is under increasing pressure from population change. An ageing population means there will be an increase in the numbers of people with chronic long term conditions such as heart failure. Under this pressure the system will evolve to focus more on preventative care than reactive management of health crises. This will entail more team based care, a focus on monitoring chronic conditions, integration across system boundaries and increased reliance on technology. These projected changes indicate that there will be increased demand for technologies that enable monitoring of long term conditions and that facilitate communication between teams, between sectors of the healthcare system and between patients, carers and clinicians.

Previous uses of remote communication and monitoring technology in healthcare suggest that there is a particular need for technology that will facilitate communication amongst geographically distributed teams and between structurally distinct parts of the healthcare system, such as primary and secondary care. There is also demand and political pressure for technology to remotely monitor patients with chronic conditions.

Scenarios can be used throughout the design process. Initially they increase designers' understanding of the work system by providing the broad cognitive and social context in which work is conducted. Later in the design process scenarios can be used to evaluate and iterate design ideas. Finally, they can be used for system testing. For a design project it is important that a set of scenarios are sufficiently broad to be representative of the domain. A set of clinical tasks was developed in order to ensure that the scenarios that were developed were representative of the major clinical tasks performed. The clinical tasks were diagnosis, monitoring, treatment planning, review, communication and consultation.

A set of 8 scenarios were developed. These scenarios were representative of the identified clinical tasks. Four scenarios were chosen for full elaboration and are presented in detail. The four scenarios were:

1. Remote monitoring for Chronic Obstructive Pulmonary Disease

This scenario describes the care of an elderly patient with COPD who is discharged home from hospital with monitoring equipment that enables his vital signs to be transmitted to a database and monitored by his healthcare team. The current and proposed new care delivery processes are shown. The scenario shows how the technology can help patients to manage their own condition, provide integration of health and social care, reduce reliance on acute care and reduce demand on residential and acute services.

2. Recurrent falls

This scenario describes the treatment of an elderly person with recurrent falls. Gait analysis is a valuable part of the assessment and treatment of elderly fallers, but is often difficult to incorporate into treatment planning because it requires specialist facilities and results are often not available in a timely manner. The scenario describes how technology could be used to facilitate timely incorporation of gait analysis results into falls assessment, treatment, monitoring and review.

3. Acute care remote consultations

This scenario describes how technology could be use to facilitate consultations between clinicians in different locations. The scenario shows how the ability to review radiology results remotely and conduct remote patient examinations could benefit patients.

4. Multidisciplinary cancer patient review meeting

This scenario describes the use of remote communication technology to enable the participation of geographically distant clinicians in a review meeting. The purpose of the meeting is to review and discuss cancer patients' diagnosis, monitoring, treatment planning and progress.

Four other scenarios were briefly described but not fully elaborated. These were:

- Dementia care co-ordination
- Labour ward foetal tracings consultation
- Process mapping
- Patient safety incident investigation

The scenarios presented in this report represent a first step in the design process. They enable a vision of the system to be developed. However, additional analysis will be necessary if planned interventions are to be successful. Insights from the field of Computer Supported Cooperative Work (CSCW) show that a systems level focus should be used when introducing new systems. This is especially the case in healthcare where complex social and organisational factors will be crucial in determining whether new systems will be effective.

Recommendations for future work are:

1. Identify a setting and healthcare partners to utilise the current technology.
2. Develop an explicit design framework within which the technology can be developed further and applied.
3. The framework should take account of the different levels of the system as discussed by Pratt et al. (2004). The framework should emphasise the users of the system, the work they have to achieve and the environment in which they work.
4. Develop a methodology for building a knowledge base for the design process and processes for the management and exploitation of this knowledge base.

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1. Introduction

Guardian Angel is a demonstration project bringing together sensor technology, body area networks and medical imaging technology in the service of health care provision. The potential applications of this project are many, including remote medical consultations between health care professionals and patients, pre-surgical planning, interactive diagnostic imaging, medical education and training.

The aim of the work in this report was to develop scenarios to envision how the technology could be used to support existing work processes in healthcare. A number of issues emerge when considering how the system might be used in a healthcare context, including:

- How people might view the usefulness of the system
- How the work environment structures work practices
- How the environment affects interaction and collaboration between people
- How people interact with system artefacts such as displays and images.
- What co-ordination and control activities are required to work effectively and safely (Perry, 2003).

In order to explore these questions and to understand under what conditions certain behaviours and phenomena occur, activities need to be contextualised with details of the work environment, in this case the health care environment (Kraut, 2003). Scenarios provide context and detail about how a system might be used. They are descriptions of a user's interaction with a system written from their perspective. Scenarios should be distinguished from simulation. Scenarios are conceptual whereas simulation is a recreation of a functional system in a controlled environment. Once scenarios are written they can be used in a variety of ways, including as the basis for modifying or extending system functionality and as the basis of system testing and evaluation with users.

In this report, we first consider the context of the changing nature of the UK healthcare system and how the pressures impinging on the healthcare system create opportunities for introducing the Guardian Angel technology. We then briefly review how technology has been used in healthcare in the past in order to identify which healthcare sectors might be more receptive to the introduction of the technology. Following this section we review scenario based design to identify how scenarios have been used to inform the design and implementation of new systems. In section 6 a framework for classifying and describing scenarios is developed and used to identify four scenarios that are described in more detail in the following section. Finally, we discuss recommendations for further work and research to carry forward the Guardian Angel project.

2. Healthcare context

In a comprehensive report on the future of the healthcare system, NHS Scotland (2005) summarised the changes that will occur in healthcare as a response to the pressures identified. One source of pressure is demographic change. The population is ageing, resulting in increasing numbers of people with multiple conditions and chronic diseases such as heart failure and diabetes. The healthcare system must therefore change from focussing on reactionary care in acute crises to providing resources for preventative healthcare in which health crises are prevented through comprehensive monitoring (NHS Scotland, 2005). Such a change will require patients and carers to be supported in managing and monitoring their own health (NHS Scotland, 2005).

A second impetus for change is the development and increasing availability of information and communications technology. This technology means that interactions between patients and healthcare providers can be conducted remotely. If the technology is also used to allow healthcare professionals to communicate remotely healthcare will increasingly become a team based collaborative activity. There would then be the opportunity to develop multi disciplinary teams that are networked and supported by remote consultants (NHS Scotland, 2005). Specialised or complex care can be concentrated on fewer sites with hospital based care based in the community (NHS Scotland, 2005).

A focus on preventative care also requires the full integration of healthcare providers such as hospitals, GPs, specialist consultants, social care providers and carers. Co-ordination across the boundaries of the healthcare system (such as between primary and secondary care) will become increasingly important, and can be facilitated by technology. Closer collaboration and co-operation between clinicians will improve the quality of healthcare.

The projected changes discussed in the report are summarised in Table 1.

Table 1. Current and evolving models of care (NHS Scotland, 2005).

Current view	Evolving model of care
Geared towards acute conditions	Geared towards long term conditions
Hospital centred	Embedded in communities
Doctor dependent	Team based
Episodic care	Continuous care
Disjointed care	Integrated care
Reactive care	Preventative care
Patient as passive recipient	Patient as partner
Self care infrequent	Self care encouraged and facilitated
Carers undervalued	Carers supported as partners
Low tech	High tech

These projected changes indicate that there will be increased demand for technologies that enable monitoring of long term conditions that facilitate communication between teams, between sectors of the healthcare system and between patients, carers and clinicians.

3. Review – technology in healthcare

In this section we briefly review some examples of how technology has been applied in different healthcare settings to support remote communication and monitoring. In this section the aim was to identify particular healthcare settings where remote consultation and monitoring technology might be beneficial. The review also identified potential scenarios that could be developed further in this work.

3.1. Primary-secondary care referrals

There is scope for remote consultation facilities in primary care in situations in which patients need to be referred to a specialist. Referrals often result in duplication of tests and inefficiencies of communication (Wallace et al. 2002). Wallace et al. (2002) evaluated the effectiveness of a teleconsultation between GPs, specialists and patients. They hypothesised that if GPs and specialists reviewed patients together more effective communication would lead to more effective management. They found that teleconsultation resulted in patients undergoing fewer tests and investigations but increased rates of out patient follow-up appointments, depending on location and medical speciality. Patients were highly satisfied with the teleconsultation, but costs were greater for the NHS.

The teleconsultation was difficult to implement because GPs had to be present at the consultation. Specialists conducted their consultations remotely and for some specialities, such as ENT and orthopaedics, were reluctant to rely on the findings of the GP examination.

A similar study was conducted by Wong et al. (2006) who compared three methods of referring patients for neurological consultation with a randomized controlled trial. The methods were telephone consultation alone, telephone consultation together with electronic transmission of brain scan images, and a real time video conference that included viewing patients and other images. Both the telephone conference with brain scan images and the video conference referrals resulted in greater diagnostic accuracy than the telephone consultation. However, they concluded that the video conferencing was not successful because of the greater length of time required for the consultation, the long set up times and problems with portability.

3.2. Surgery

Den Hartog, Schmidt & de Vries (2006) introduced personal networks in a hospital setting. This enabled voice and data communication with remote content and services. They studied the utility of introducing personal networks in hospital surgeries where surgeons could control a video recording of the progress of surgery for download and viewing by remote specialist consultants who could contribute expertise to the case, or medical students and registrars. They used a combination of individual content interviews, scenarios and requirements verification combined with focus groups to assess the acceptability of this technology.

Their results showed that potential users thought the technology would be useful for accessing patient files from multiple locations, educating students, a senior surgeon supervising several operations simultaneously, regional specialist meetings and transfer of information between hospitals.

3.3. Intensive care

The introduction of technology to support remote intensive care teams who can monitor patients and interact with patients and staff is being driven by shortages of intensive care staff, particularly in the United States. There are currently at least 30 remote ICU systems implemented in the United States (Breslow, 2007). The delivery of care is shared between on site staff and remote intensivists who together provide continuous monitoring of critically ill patients. The technology consists of bedside audio video equipment that allows remote care providers to see and interact with patients and staff. Interaction can be initiated by either on site or remote staff. The remote staff can also view bedside monitor data including real time data and all clinical data including x-rays, although these systems are not always integrated. Alerting systems are also used that can provide early warning of developing problems. The video system is capable of zooming in to view ventilator screens, infusion pumps and other data sources, and is sensitive enough to allow the remote team to assess the patient for clinical signs such as neurological function, respiratory function and skin colour (Breslow, 2007).

These systems require the re-organisation of the delivery of care, which often requires a change in the culture and would not work without the commitment of key healthcare staff. The existence of strong leadership is essential for the success of such a major intervention (Breslow, 2007).

Evaluations of the effectiveness of remote intensive care teams have been encouraging. Breslow et al. (2004) compared care outcomes before and after the introduction of a remote monitoring system for ICU care. Off site intensive care clinicians provided remote monitoring and management of ICU patients. They found that mortality was lower and length of stay was shorter during the first six months of the intervention compared to before the remote program was introduced. Hospital costs were also lower and higher revenue was generated through higher patient volumes. Similar results were found by Rosenfeld et al. (2000) using an observational time series triple cohort study. They found that mortality was reduced; complication and length of stay decreased with associated cost savings.

3.4. Management of patients at home

Telemedicine has been used for monitoring the vital signs of patients with long term chronic conditions such as diabetes, chronic obstructive pulmonary disease and heart failure. Systems commonly use sensors which can monitor physiological parameters such as heart rate, oxygen saturation and blood pressure. These are transmitted to a database and a healthcare provider is alerted if vital signs fall outside a pre-determined safe range. These systems are reactive and preliminary data from a trial in Surrey indicates some difficulties with the reliability and acceptability of the devices (Anderson & Horton, 2007).

There is currently major investment in increasing uptake of telecare for monitoring long term conditions. The Preventative Technologies Grant provided £80 million over two years from 2006 to enable more older people to remain independent at home. In addition, the Department of Health is funding Whole System Demonstrators to integrate telecare into health and social care services.

3.5. Conclusion

This brief review indicated that there is a potential need for technology that will bridge the gaps between sectors of the healthcare system, such as primary care and secondary care. The results also suggest that it is difficult to implement technology interventions in clinical practice because of entrenched working patterns and practices. There are also situations in which there is a need to gain specialist input and skills into cases and this requires a means to collaborate and consult with colleagues who may not be in the same geographical location. Finally, many pressures in the healthcare system are driving demand for remote monitoring technology but many projects designed to introduce telemedicine are at the pilot study stage only.

4. Scenario based design

Scenario based design is a technique for generating concrete and specific examples of work activities in order to inform the design of future computer systems (Carroll, 1995). The use of scenarios in human computer interaction is linked to other participatory design approaches that emphasise the importance of capturing the users' perspective. These include contextual design, which uses ethnographic methods to understand human behaviour (Mack, 1995). All participatory design approaches emphasise the importance of understanding the perspectives of users in order to ensure that systems effectively support their work. Scenarios can be particularly helpful in showing how a new system might change or impact upon users' activities (Carroll, 1995). This is especially important if the future system is to be usable and if the problem domain is unfamiliar to the system developers (Grudin, 1993).

Scenarios can also be used across the system development life cycle to inform design. At the initial stage of the design process, Mack (1995) argued that scenarios increase designers' understanding of the broad cognitive and social context in which work is conducted. Task analyses may also be used but focus on a detailed understanding of user behaviour whereas scenarios have a broader focus. At this stage, scenarios are used to define the broad goals of the system, build a cohesive vision for the system and to mobilise support for the design process (Mack, 1995).

During later stages of the design process, scenarios are used to generate design ideas which are then evaluated and iterated. The scenarios also evolve with the design process as a deeper understanding of the domain is acquired (Mack, 1995). Scenarios are used at this stage to add details to the design requirements and to suggest design possibilities. Finally, scenarios can be used to guide user or product testing by providing detailed examples of how the system can be used (Mack, 1995).

The content of scenarios can vary depending on the purpose for which they were developed and at what stage of the design lifecycle they will be used. Initial scenarios might be high level narratives based on current practices while scenarios developed later in the design process will focus on how existing practices could be modified by the system. Scenarios that guide testing and evaluation should include detailed concrete descriptions of tasks and actions (Mack, 1995). Different types of scenarios might also be needed. Carroll (1995) argued that both context and application scenarios are needed. Context scenarios describe the work practices and the context in which a system is used without giving details of how the system works whereas application scenarios describe how the system will operate.

Scenarios are often incorporated in software design projects but have been used less frequently for the design of medical systems. There are two important characteristics of healthcare work which are central to whether new systems will be successful. First, health care is collaborative. Many people are involved in the care of one patient, necessitating many handovers of care when shifts change or when patients are transferred to different parts of the healthcare system. The frequent transfer of care from practitioner to practitioner creates a need for co-ordination so that there are no gaps in patient care. Second, healthcare is often non routine because there are frequent exceptions and emergencies. (Xiao, 2005).

Moreover, the people in healthcare are often geographically separated from each other. Research shows that distributed groups do not work as effectively as co-located groups (Kraut, 2003). Geographically distributed teams have difficulty setting direction, co-ordinating work and forming successful relationships. A means to communicate directly and interactively is essential, especially if they are working on tasks that are not highly routinised and where the problems are not straight forward. Designing systems for this environment is complex because such work activities are likely to be open-ended and involve variable numbers of actors. There are usually multiple, co-dependent users who work together on ill structured tasks (Kraut, 2003)

Although scenarios have been used less frequently for collaborative system design, Bardram (2000) made extensive use of scenarios in the re-design of a hospital information system. To guide the design process the team used a series of detailed organisational overviews describing the organisation, work roles, artefacts and spatial and temporal characteristics of work. These were complemented by Work Activity Scenarios that were used, modified and developed throughout the design process. Two sets of scenarios were maintained; one addressing current work activities and one addressing future imagined work activities. These were supplemented by activity maps that described the interdependencies among activities and analytical scenarios that provided a detailed analysis of collaborative activities including distribution among actors, the use of artefacts, location in time and space and purpose.

Bardram (2000) argued that the design of collaborative work systems is challenging and scenarios offer a way to bridge the gap between designers and users which often arises when ethnographers carry out studies of collaborative activity and brief the designers.

This report draws on the ideas outlined by Bardram (2000) and others to link system designers with the healthcare domain. The scenarios developed and described in the following sections are high level conceptualisations of how current work practices could be enhanced with remote communication and sensing technology.

5. Scenario characteristics

A design project will require numerous scenarios throughout the design process and it is important to ensure that the set of scenarios that are developed are representative and comprehensive, with minimal overlap and with sufficient complexity to guide design (Rosson & Carroll, 1995). Task taxonomy can be used to guide scenario collection and development. Rosson & Carroll (1995) developed a generic typology of six usage situations that they hoped would be general enough to apply to many situations. Their six usage situations were:

1. Orienting to goals. A first time user needs to explore what a system does.
2. Opportunistic interaction. Exploring one aspect of a system.
3. Searching for a function to complete a task.
4. Carrying out procedures or tasks. Goal directed.
5. Making sense of the system. When a problem is encountered, understanding why the system does what it does.
6. Reflecting on skills and planning actions based on knowledge. Optimising tasks.

This typology is clearly relevant to tasks in which an individual interacts with a system to achieve a clearly defined goal. However, in many situations workers are required to interact with each other and the system to co-ordinate their activities. In a collaborative work setting such as healthcare it would be more useful to focus on the generic tasks that practitioners have to perform and that could be supported by technology. In this section we developed a description of the major task categories in healthcare that could be supported by remote communication and sensing technology. The task categories and description are shown in Table 2.

Table 2. Clinical task categories.

Task	Description
Diagnosis	The process of identifying a condition or disease. A diagnosis is based on information gained from the history, the results of medical tests and physical examination.
Monitoring	Monitoring of specific physiological parameters is conducted to detect unexpected changes or departures from normality. Monitoring can identify when a particular goal state has been achieved, often in response to a treatment. Monitoring can be continuous or conducted at specified intervals and may involve invasive or non-invasive procedures.
Treatment planning	The process of deciding which remedies to administer for a disease or injury. Includes medicinal or surgical management.
Review	The process of critically evaluating a patient’s treatment or diagnosis to evaluate their appropriateness or effectiveness.
Communication	The process of sharing clinical information about a patient’s condition or treatment
Consultation	A meeting held to discuss a particular topic. In clinical care the discussion would be about the diagnosis, prognosis and treatment of a particular case. Views are exchanged and advice is given.

The task categories were then used together with the review of how technology has been used in healthcare previously to generate a list of potential scenarios. The aim was to ensure that the scenarios were representative of the tasks that healthcare workers have to perform and that as many healthcare sectors as possible were included. From the list of 9 scenarios that were generated, four were chosen for full elaboration and these are contained in sections 6-9. Access to specialists who could provide information about the scenario determined to some extent which scenarios were chosen for full elaboration. The remaining scenarios are described briefly in section 10 but were not fully elaborated.

Table 3. Summary of healthcare scenarios.

Scenario title	Scenario description	Health care Sectors	Clinical tasks
Remote COPD monitoring	Full	Primary care Acute care	Monitoring
Recurrent falls	Full	Primary care Secondary care	Diagnosis Treatment planning Monitoring
Acute care remote consultations	Full	Secondary care	Diagnosis Consultation
Multidisciplinary cancer patient review meeting	Full	Tertiary care	Diagnosis Monitoring Treatment planning Review Communication Consultation
Dementia team co-ordination	Brief	Primary care Secondary care Social care	Monitoring Treatment planning Review Communication Consultation
Labour ward foetal tracings consultation	Brief	Secondary care	Diagnosis Monitoring Consultation
Process mapping	Brief	Administrative	Consultation
Patient safety incident investigation	Brief	Administrative	Consultation

6. Scenario 1. Monitoring COPD patients in the community

This scenario is based on the experiences of a patient with Chronic Obstructive Pulmonary Disease (COPD).

6.1. Background

The NICE (2004) guideline offers best practice advice on the care of adults with long term conditions such as Chronic Obstructive Pulmonary Disease (COPD) which includes chronic bronchitis, emphysema, and chronic airflow limitation/obstruction. The guideline is relevant to primary and secondary healthcare professionals who have direct contact with such patients, and make decisions about their care.

The NICE guideline also suggests that local health communities should review their existing practice for the management of these patients against this guideline as they develop their Local Delivery Plans. Hence the organisational context in which COPD care is delivered in both primary and secondary settings has implications for patient outcomes.

The use of telemonitoring has been reported in a variety of forms and recent applications cover activities such as remote consultations in specialities from dermatology to psychiatry, the transmission of electrocardiograms and radiological images, and education for health professionals (Currell et al., 2000).

6.2. Current care delivery process

In a local Primary Care Trust, an intermediate care team is responsible for caring for COPD patients following hospital discharge. .The COPD at Home Scheme as it is known, offers a team approach to care. Patients would initially be seen and assessed by a team member at the hospital to decide whether they meet the criteria for the scheme. Current care delivery process
If patients fulfil the criteria for acceptance onto the scheme and are willing to be managed at home they are discharged home and managed in the community by the COPD at Home team during the acute period (average 5 days). The team liaise with GPs and community teams involved in the patient's care and make referrals to other members of the primary care team as appropriate. These include key care, district nurses and practice nurses.

Once the patient is discharged home, they would be seen by a member of the team who will decide on the type and frequency of nursing interventions required (e.g. home visits, telephone calls, observations). Patients are generally discharged from this scheme within 5-7 days. Patient care plans are held at home by the patient. Patients would be admitted to the ward if they had elevated respiratory rate, heart rate, temperature, carbon dioxide levels, they are confused or have a co morbidity necessitating admission.

6.3. Problems experienced in the system currently

The use of remote monitoring would address current problems in the health care system including:

High hospital admission rates

Reliance on management of acute crises rather than prevention of crises

Patient over-reliance on care providers,

Patients' low quality of life

Patients' inability to exercise self reliance and independence.

6.4. Proposed new care delivery process

Following the decision to discharge the patient home on the COPD at Home scheme the patient is offered the opportunity to use remote monitoring equipment that would enable their vital signs to be transmitted to a database and monitored by their healthcare team.

The system would analyse the readings made by the patient and instigate the following actions:-

Alert the patient's practitioner to the fact that the patient has exceeded the parameters set by the practitioner, or has failed to submit the information requested.

Generate trend reports for review by the practitioners

Consultant Physicians are clinically responsible for the medical treatment of patients although some clinical decision making may be made by the intermediate care team.

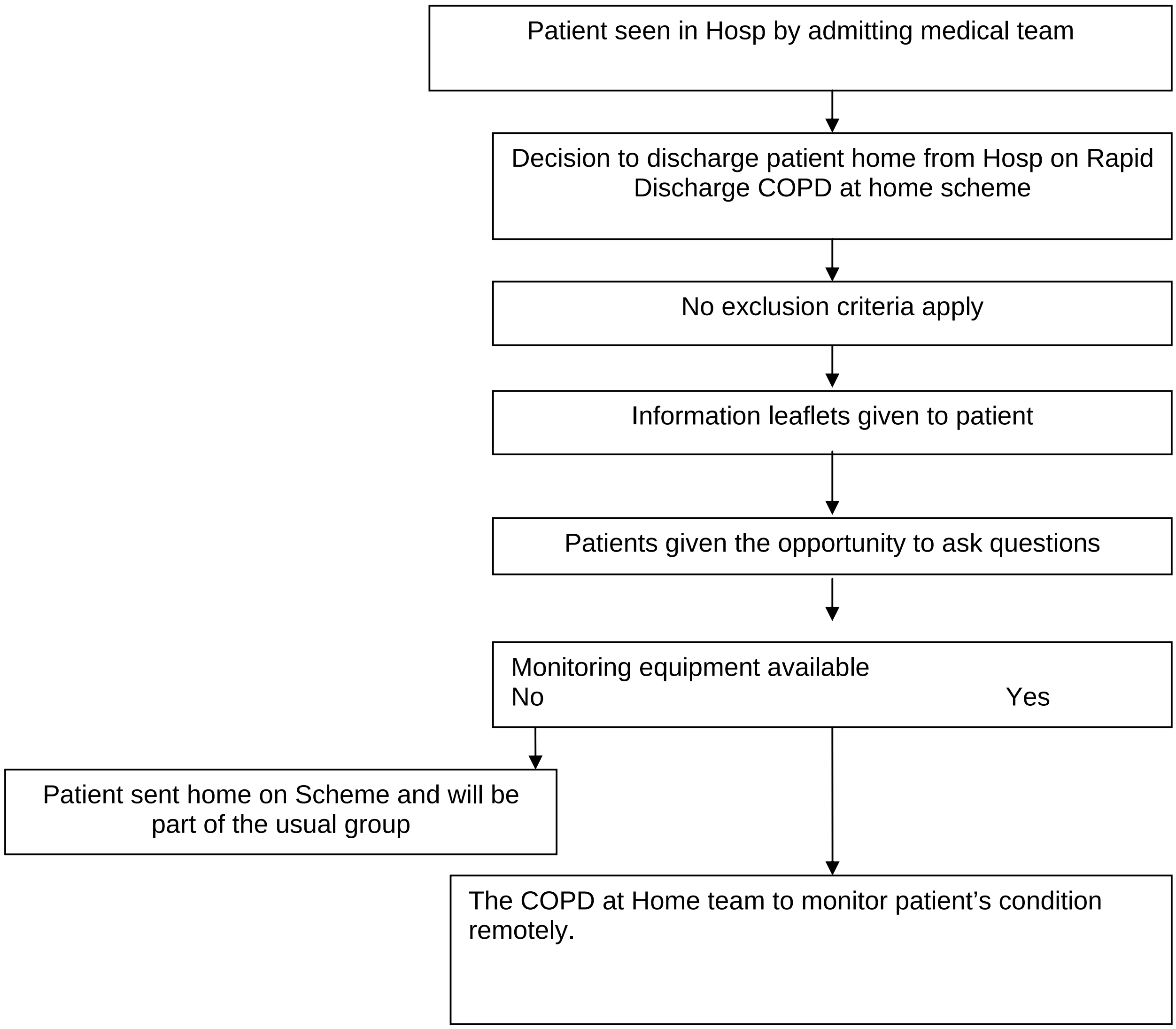

Figure 1. Proposed new care delivery process for COPD monitoring.

6.5. Scenario description

Mr K was a gentleman aged 68 years and fully independent in all activities despite having COPD and heart failure. He was admitted to hospital following an acute exacerbation of his COPD. After a course of antibiotics, he was well enough to be discharged home but will continue to have his BP and cardiac tracing monitored daily at home.

Following installation of the monitoring equipment Mr K managed the equipment and input of information onto the system independently. During the second week alerts were received showing irregularities in the cardiac tracing and a bradycardia of 40 beats a minute. A telephone call was made to Mr K who reported feeling unwell with less energy than usual.

From this information a Rapid Access Clinic appointment was made for the following day. As a result Mr K had a consultation with a cardiologist which resulted in a change of treatment and medication.

Mr K used the monitoring equipment for a further two weeks with no alerts shown in that time. Mr K was discharged and the equipment removed.

Mr K stated he felt much better and was now confident to go on holiday with his family.

6.6. Conclusion

This scenario shows how remote monitoring equipment could provide the following benefits:

People with a chronic disability and their carers are helped to manage their own condition with an emphasis on appropriate intervention and support.

Patients' understanding of their condition is developed and they are more involved in their care plan through the enablement of prevention.

Integration into a single system of health & social care, delivered by staff working across traditional organisational boundaries.

Enhanced rehabilitation, as part of a continuum of care where patients are helped to reach their maximum potential by reducing their reliance on acute care.

Reduced demand on residential care and acute services, leading to cost savings.

7. Scenario 2. Recurrent falls

7.1. Background information

Falls are a common source of injury in the elderly. Falls are usually caused by a number of factors including muscle weakness, cognitive impairments, depression, and medication. Gait abnormalities are often also involved. It is therefore necessary to perform a thorough analysis of the causes of falls before instigating recommendations for treatment. Treatment for falls includes balance and strength training, correction of vision and hearing, medication changes, postural exercises, patient education, analysis of environmental barriers and gait retraining. Gait analysis can be used to assess the efficacy of particular interventions, such as strengthening exercises, changes in medication dose or initiation of drug therapy.

7.2. Current care delivery process

The current care delivery process is complex and can involve the GP, hospitals and specialist falls services. A thorough assessment is completed for all patients who fall (see Appendix 1). However, a complete gait analysis is usually not included in the investigations. Figure 2 shows the current care delivery process.

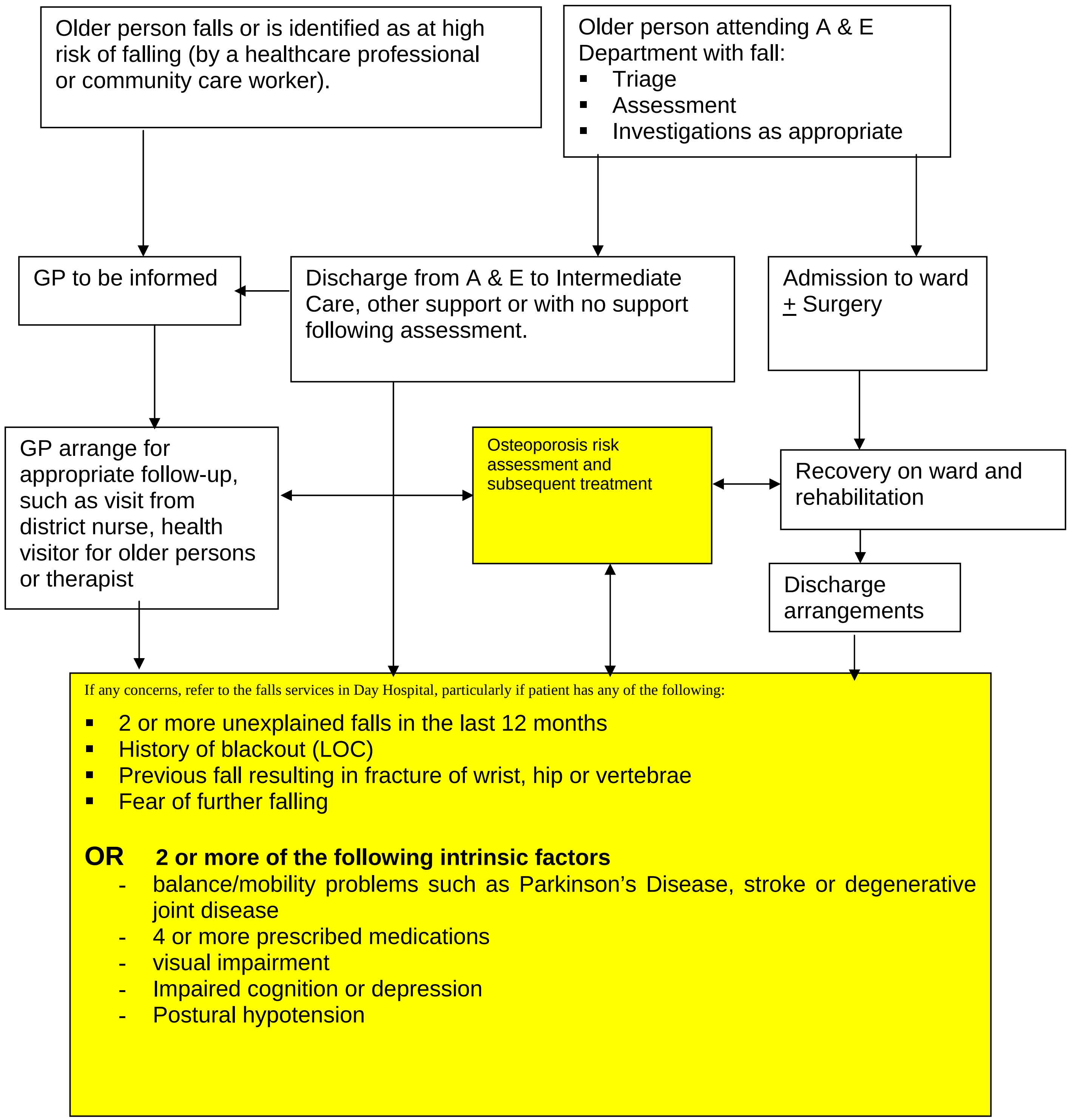

Figure 2. Current care delivery process for falls patients.

7.3. Problems experienced in the system currently

Gait analysis is usually performed in specialised laboratories and this creates the following problems:

- Access to the facilities is difficult and therefore gait analysis is not often performed
- If gait analysis is conducted it is often difficult to incorporate the results in a timely way into the diagnosis and treatment plan.

If gait analysis results could be accessed remotely at the time that the patient was assessed by the GP then gait analysis could inform the diagnosis and treatment of the problem to reduce the risk of falling.

7.4. Proposed new care delivery process

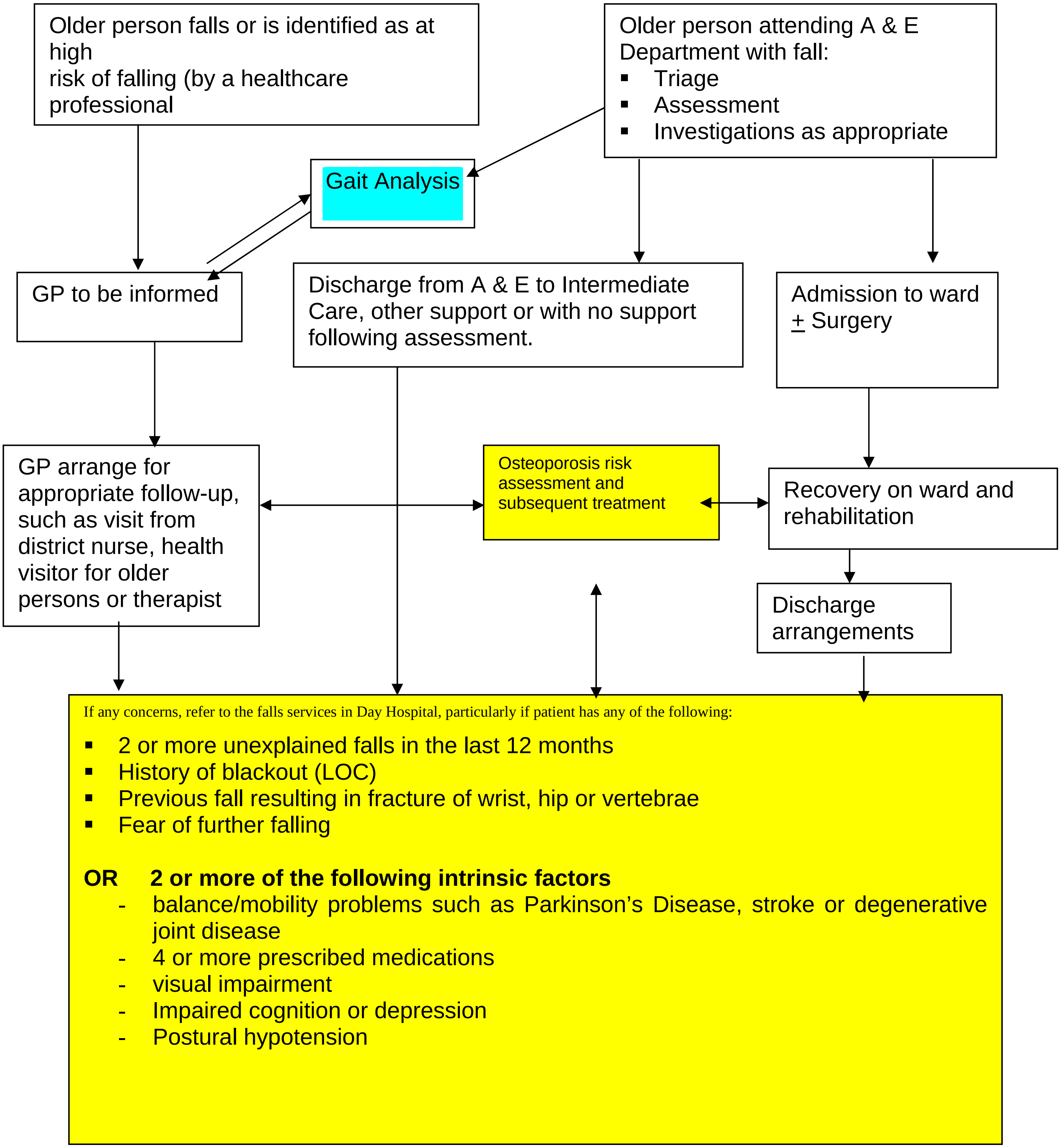

Figure 3. Proposed new care delivery process for falls patients.

7.5. Scenario description

Mr. W is 86 and lives independently in his own home. He suffers with dementia, has frequent falls due to his low blood pressure, poor mobility and is very deaf. He had a fall during the night and had lain on the floor until he was found in the morning by his carers. His GP was called; he examined Mr. W and decided that he needed to be admitted to hospital for investigation. An ambulance was called.

At the A&E department, an assessment was undertaken by the medical officer for Care of Elderly Services. He was to be admitted to the ward for further investigations

Although family members and carers have noted that Mr W has had mobility problems, there has not been any clinical assessment to determine the actual problem. A Gait Analysis would help to identify what gait problem exists and offer solutions to prevent future falls. A referral for such an assessment was made by the Consultant Geriatrician. Mr W was to be discharged home the next day with a follow-up appointment for a Gait analysis.

A Gait analysis was conducted by a specialist Scientist Engineer who runs the Gait Analysis lab on a weekly basis. This included the following:

- Capture postural and gait stability data for the calculation of the risk of falling.
- Measurement of body sway and gait temporal-spatial parameters will be taken and logged;

Equipment that needs to be available to do a Gait Analysis includes:

Balance force plate and walkway
Plantar pressure e.g. Scan
Video (2 camcorders and mixer and recording deck)
Energy expenditure e.g. HR Polar
GaitRite portable instrumented walkway
Portable Computing – Laptop
Data acquisition board
Software, support licenses, maintenance
Fscan insoles
Storage of data/video etc

The gait analysis was logged on to a video that could be assessed directly by the consultant geriatrician at the acute hospital trust and/or GP who can assess the data at the same time. Based on the findings of the gait assessment, a decision is made by the consultant and/or GP on appropriate fall prevention intervention(s).

Mr W was relieved that the doctors are now aware of his mobility problems. He has been advised on the types of exercise to do in order to improve his mobility. He will attend the gait analysis lab at monthly intervals to assess whether the exercises are having the appropriate effect on his gait and therefore reducing his risk of falling. His clinician will continue to access the gait analysis results remotely and will adjust his treatment as necessary.

7.6. Conclusion

The tri-partite arrangement between the Scientist Engineer, Consultant Geriatrician and the GP can result in a more integrated person-centred approach to falls management.

8. Scenario 3. Acute care remote consultations

This scenario is based on a case that occurred in a London hospital following laparoscopic surgery. Because the patient presented at her local hospital with post operative problems, her condition could not be assessed by her surgeon, based in London, without her being transported to London so that he could see her. The scenario envisions how remote consultation could have facilitated diagnosis of her condition.

8.1. Background information

Laparoscopy is a common surgical procedure that is used for diagnostic purposes and to carry out many surgical procedures. Laparoscopic surgery avoids the need for a major surgical incision and therefore reduces patient recovery time. The laparoscope is a thin long instrument with a light at the tip which can be moved around to view various organs. It is commonly linked to a video monitor allowing others to view the progress of surgery.

The procedure requires at least two small incisions in the abdomen. Through one incision a thin tube connected to a supply of carbon dioxide gas is inserted. The carbon dioxide is pumped into the abdomen to raise the abdomen wall, allowing the laparoscope to be inserted and the organs to be viewed easily. The laparoscope is inserted in the second incision and sometimes further instruments need to be introduced through more incisions.

Following the procedure the carbon dioxide that was pumped into the abdomen is gradually absorbed by the body. Before this happens the patient may experience some abdominal pain or referred pain in the shoulders due to the presence of the gas. Some patients also experience nausea and vomiting due to the effects of the anaesthetic. The most serious complications of laparoscopy occur when the laparoscope damages other internal organs such as the bowel, major vessels or the oesophagus.

This scenario is based on a case report of a patient presenting at the A & E department of her local hospital the day after laparascopic surgery. She was in pain and had experienced vomiting. On examination she was found to have subcutaneous emphysema, which could indicate either rupture of the oesophagus or normal after effects of the laparoscopy. Her biochemistry results were clear and her CT scan was not easy to interpret. The consultant therefore contacted the surgeon who had performed the procedure. He reviewed the biochemistry results and the results of the physical examination, but could not review the CT scan and could not see the patient to assess her well being. In the absence of this information he arranged for the patient to be transported to the hospital where the procedure was carried out. On examination he diagnosed normal side effects of laparoscopy and after being kept in hospital for observation the patient was discharged the following day.

The surgeon’s opinion was that this case could have been resolved quickly and with less cost and inconvenience to the patient if he had been able to review all the relevant information and if he had been able to visualise the patient.

8.2. *Current care delivery process*

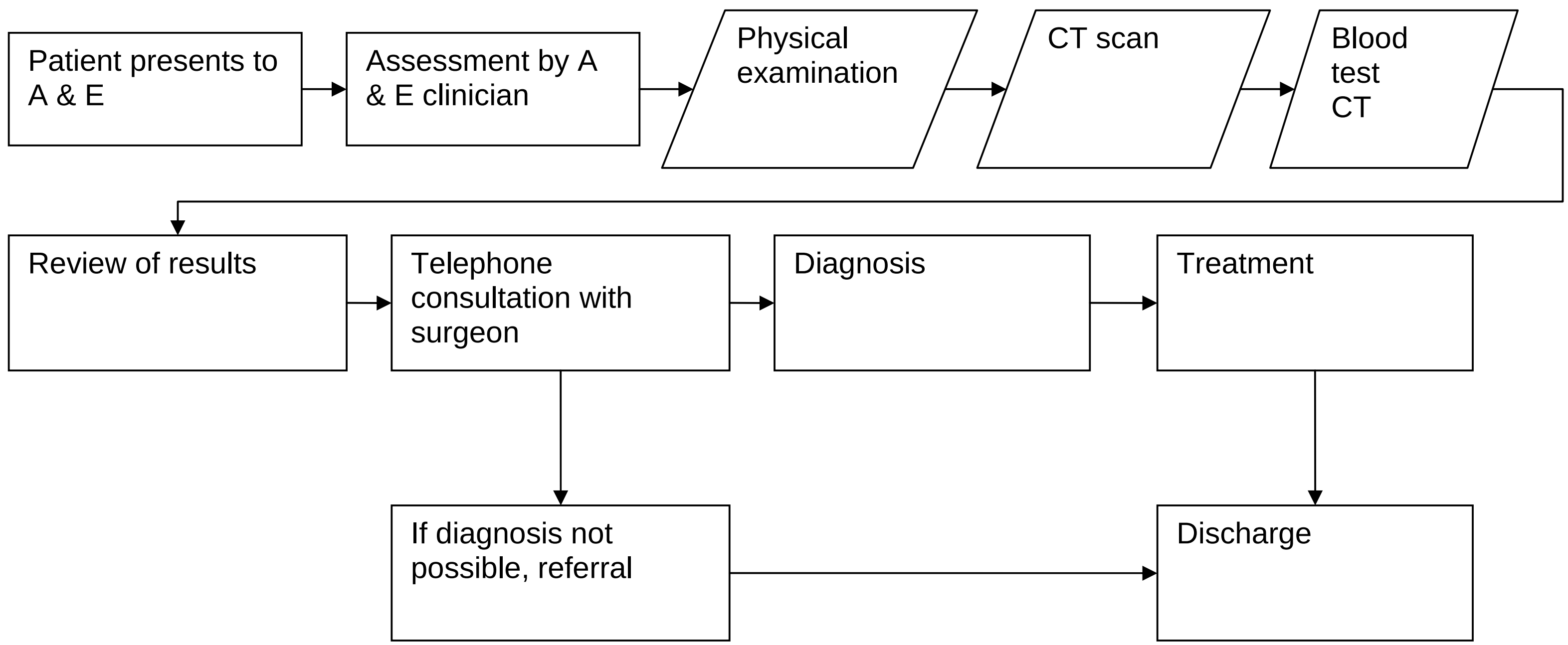

Figure 4. Current care delivery process acute care scenario.

8.3. Problems experienced in the system currently

The surgeon who performed the laparoscopy was crucial in assessing whether her condition was due to an operative injury or severe, but normal, post operative side effects. However, without access to the CT scan and without visualisation of the patient he could not diagnose the problem. This resulted in the expense and discomfort of the patient being transported to London where he could make a confident diagnosis.

8.4. Proposed new care delivery process

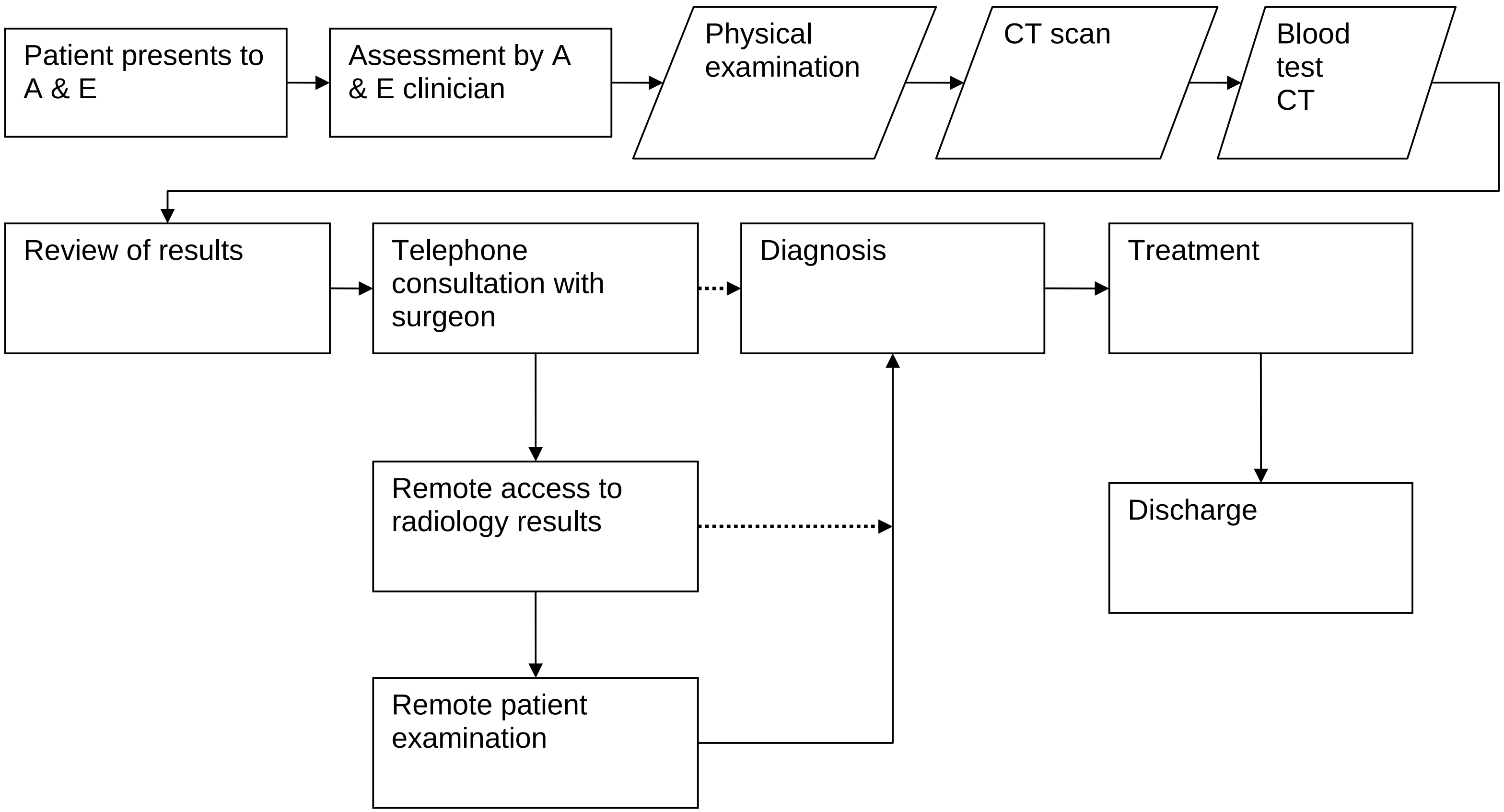

Figure 5. Proposed new care delivery process acute care scenario.

8.5. Scenario description

The patient was a healthy 53 year old female who underwent a laparoscopy to repair a hernia. A surgeon carried out the laparoscopy at a major tertiary referral hospital in London The procedure was straightforward and successful. The following day she attended the A & E department of her local hospital reporting severe chest pain and vomiting.

The A & E consultant examined the patient and found signs of subcutaneous emphysema. A CT scan was taken but the results were difficult to interpret. Biochemistry results were normal. The subcutaneous emphysema could have resulted from the normal presence of carbon dioxide following the laparoscopy, or from a rupture of the oesophagus caused by the laparoscope. Rupture of the oesophagus is a serious complication of laparoscopy and requires immediate surgical repair.

The consultant contacted the surgeon using the remote consultation system. The surgeon reviewed the biochemistry results and the CT scan, which he agreed was difficult to interpret. He needed to see the patient to form a definite diagnosis. A remote consultation was set up so that the surgeon could see and interact with the patient. He knew the patient very well. Because she looked relatively well he formed the opinion that she was suffering from the normal side effects of a laparoscopy with no rupture of the oesophagus. He advised that she remain under observation over night. The next day she was better and was discharged.

8.6. Conclusion

This scenario illustrates the importance of team work in health care and the difficulties of co-ordinating care across geographical locations. In this case the patient was transported some distance so that the surgeon could make a diagnosis, but he affirmed that a good remote consultation system would have avoided the cost, inconvenience and discomfort of transporting the patient. He highlighted the need for such a system to be mobile and to include a facility for visualising and interacting with patients as this information is as important clinically as test and imaging results.

In addition, specialist clinicians working in tertiary referral centres often work across sites. Patient consultations, observations and notes might be at one site while operations are carried out at another site. Clinicians therefore spend a lot of time travelling between sites. A remote consultation and imaging system would be extremely beneficial in such cases.

9. Scenario 4. Multidisciplinary cancer review meeting

This scenario was based on discussions with a cancer care clinician and observations of a multidisciplinary review meeting.

9.1. Background information

This scenario is based on discussion with a specialist cancer surgeon working at a tertiary referral hospital in London. Tertiary care refers to specialised treatment provided at a small number of locations in state of the art facilities. Referrals to tertiary care are usually made by specialists. Multidisciplinary meetings of specialists from across London are held to review cases. The purpose of the meeting is to discuss cases and make decisions about diagnoses and ongoing management. Decisions made at the meeting are documented.

9.2. Problems experienced in the system currently

Since the participants in the meeting are highly specialised clinicians, their availability to attend the meeting is often a problem. The clinicians are in high demand and sometimes cannot take time to travel to the meeting. It is likely that absences decrease the effectiveness of the meeting by reducing the amount of specialist input available to the discussion. Although there is a facility to share information using a web link the connection is slow and the quality of images is very low and so it is not often used. However, a facility that allowed remote consultation and viewing of images and results with good quality and good response time would be very useful for allowing people to participate who couldn't attend in person

9.3. Scenario description

The meetings are held weekly and are attended by physicians, surgeons, radiologists, pathologists and students. Usually there are between 15 and 20 attendees. Clinicians present a short summary of their patients and the issues they wish the meeting to consider. Pathology and radiology results are shown on screens during the meeting and discussed with specialists.
The following patients are presented by a surgeon attending the meeting via a remote link from another hospital. He is able to view the radiology and pathology results and participate in the discussion.

- An existing patient, male 68 years old was presented. He has a 39 centimetre polypoid tumour in the gastric cardia. The tumour could be seen on the CT scan. At a previous meeting it was agreed to perform an exploratory laparoscopy. On laparoscopy there was no tumour in the upper stomach or abdomen, but something hard could be felt in the hiatus. There was a lesion on the left lobe of the liver. The pathologist reported that it was benign and images of the pathology were shown. The meeting decided that chemotherapy should be started, a PET scan should be performed and the case reviewed later for possible surgery or endoscopic ultrasound aspiration.

- An existing patient, male 51 years old was presented. He had a history of moderate to severe dysphagia and diabetes. He had a large T4 tumour in the hiatus, and emphysmatic lung nodules. At the previous meeting a CT scan had been requested. The CT scan was viewed and the radiologist showed that the nodules appeared to be round and was of the opinion that they could be metastatic. A PET scan had been performed and was reviewed, but was hard to interpret because of reduced clarity due to diabetes. The meeting decided to insert an oesophageal stent to palliate eating problems and to start chemotherapy. At a later meeting the effect of chemotherapy on the pulmonary lesions would be reviewed.
- A patient with a recurrence of oesophageal cancer was presented. He was male, aged 72 years. He had a chest wall deposit and had previously had a good response to chemotherapy. His GP had detected a lump. A previous meeting had agreed that management should be a transhiatal oesophagectomy and had requested a PET scan. The PET scan was reviewed and the radiologist revealed a lesion on the rib which could be metastatic. Discussion ensued about whether the lesion could possibly be an operative track. The meeting decided to treat with radiotherapy and review.
- A patient was presented for review. He was male 57 years old. A second opinion had been requested for this case. He had a history of dysphagia and stricture of the oesophagus. A CT scan showed a tumour in the lower oesophagus extending into the stomach. A later CT scan showed a fluid filled tumour with no lymph involvement, no metastases. A laparotomy confirmed these results but no biopsy had been taken. The meeting decided that he needed a radical gastrectomy, but it was not clear how far up the oesophagus the tumour extended and so it was unclear how much of the oesophagus would need to be removed. The meeting discussed the possible need for repeat endoscopy, CT scan and PET scans. The meeting decided to continue with chemotherapy and restage after 3 cycles.

9.4. Conclusion

This scenario shows the importance of collaboration and team decision making in the management of cancer. Remote collaboration technology could ensure that clinicians are able to collaborate and pool their expertise even when they are geographically distributed. The sharing of images and test results is crucial in this process. Participants in the meeting also reported that it would be crucial to be able to interact visually with all the participants at the meeting to ensure the maximum benefit. They felt that audio communication only was too impoverished when discussing their work.

10. Brief scenario descriptions

In this section the remaining scenarios identified in Table 3 are briefly described. The intention is to provide some background information to inform decisions about potential future scenario development.

10.1. Dementia team co-ordination

Dementia care is multi disciplinary, involving nurses, GP's, psychiatrists, psychologists and social workers. There is a need to co-ordinate the activities of these professionals so that all are aware of the diagnosis, treatment plan and any developing problems. Ongoing management needs to be reviewed with the input of all who have been involved with providing patient care. As with the multidisciplinary cancer review scenario, it is difficult to always have all participants present at team meetings. A means to remotely review documentation and test results and consult about cases would alleviate some of the problems that occur when all team members cannot be present at meetings.

10.2. Labour ward foetal tracings

Foetal heart rate monitoring is widely used for monitoring intrapartum foetal health to prevent brain injury and death (Graham et al. 2006). However, the interpretation of heart rate tracings is not straightforward. It is estimated that 60% of tracings in labour are abnormal but most of these are not associated with foetal distress (Freeman, et al. 2003). Differential diagnosis is therefore difficult and there are high rates of false positives, leading to unnecessary interventions (Freeman et al. 2003). Because of the high variability of foetal heart tracings and the difficulties of interpreting them, it would be helpful for labour ward staff to be able to remotely consult specialists who can help in interpretation and decision making.

10.3. Process mapping

Process mapping is increasingly being used in healthcare to aid standardisation of care, and to enable examination of processes for safety or efficiency. For example, Integrated Care Pathways (ICPs) provide guidance on agreed practice for specific patient groups such as stroke patients (Taylor, 2006). An ICP is a document that sets out the care process and the targets that define good quality care. They are developed by the multidisciplinary team that deals with the patient. For stroke patients, this includes a doctor, pharmacist, dietician, occupational therapist, nurse, physiotherapist, speech therapist and social worker (Taylor, 2006). At least three meetings of these professionals were required to agree on a draft ICP in stroke care (Taylor, 2006). A means to remotely collaborate, view and amend documents would facilitate this process.

10.4. Patient safety incident investigation

The formal investigation of patient safety incidents involves a multi disciplinary team, often comprised of people from different sites to the one where the incident occurred. It would be useful to have the facility to share and review documentation and consult other members of the team during the course of the investigation.

11. Conclusion

Scenarios provide a means to envision how a new system might operate and can identify opportunities for introducing new technology into healthcare. However, healthcare is a very complex system and the failure of medical information systems is high, ranging from 30-50% (Pratt et al., 2004). The high rate of failure is not always due to technical factors but rather to the complex organisational and social factors that affect healthcare practice. In particular, entrenched working practices and behaviours, both at the organisational, individual and team levels strongly affect whether a new system will succeed or fail. Therefore, it is important to employ a broad analytical perspective when implementing new systems in healthcare (Pratt et al, 2004).

The scenarios presented and elaborated in this report represent a first step in the design process and serve the purpose of providing the broad context in which healthcare work takes place. They enable a vision of the system to be developed. However, additional analysis will be necessary if planned interventions are to be successful.

Insights from the field of Computer Supported Cooperative Work (CSCW) could be useful in conceptualising what the next steps should be. CSCW addresses the question of designing systems in which people work collaboratively with each other and with tools to support their work. The focus of CSCW research is not on individuals, but on the cognitive distribution of resources and how these are co-ordinated to achieve the aims of the workplace.

In contrast, many new systems are evaluated by concentrating on the individual end user and their interaction with the system without taking into account collaborative activities. However, the introduction of new systems often changes the collaborative environment in which the system operates which in turn affects how individuals use the system (Chiasson, Reddy, Kaplan & Davidson (2007). For example, in a study of a computerized clinical order system Davidson (2000) found that although some changes in practice following the introduction of the system were beneficial, communication was now structured in such a way that ambiguity was common and efficiency was affected. Clearly, the unit of analysis should be on the way people co-ordinate their work and how to support that co-ordination.

In discussing how ideas from the tradition of Computer Supported Co-Operative Work could be applied to medical work, Pratt et al. (2004) argued that there are five levels of analysis that are important when introducing new systems. First, the political level considers both legislative impacts and also whether and in what way the proposed changes assist the government. Second, the institutional level considers the long term cultural environment and how it shapes behaviour and actions. Third, the organizational level of analysis considers how groups structure and co-ordinate their activities. Organizations are more flexible in how they arrange their activities than institutions. Fourth at the small group level of analysis there is great flexibility in how activities are organised, but collaborative activities shape and constrain individual actions. Finally, at the individual level of analysis, the cognitive activity involved and individual preferences and capacities affect how a system is viewed.

Accordingly, we make the following recommendations for future work.

1. Identify a setting and healthcare partners to utilise the current technology.
2. Develop an explicit design framework within which the technology can be developed further and applied.
3. The framework should take account of the different levels of the system as discussed by Pratt et al. (2004). The framework should emphasise the users of the system, the work they have to achieve and the environment in which they work.
4. Develop a methodology for building a knowledge base for the design process and processes for the management and exploitation of this knowledge base.

The work described above could form the basis of a joint funding proposal between researchers in the Faculty of Health and Medical Sciences, healthcare partners and researchers from the Faculty of Engineering and Physical Sciences. We would be pleased to collaborate further with the Guardian Angel project and are grateful for the opportunity to carry out the work contained in this report.

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13. Appendix 1. Assessment of falls patients

To be completed by healthcare professionals	
Name	**Address**
Date of Birth	Telephone number:
GP Name and Address	**Next of Kin**
Telephone number:	Name: Address: Telephone number:
Referred by	**Address**
Date of Referral	

Falls History - History of falls and coping strategies
No. of falls: Where fall happened (indoor/outdoor): If indoor ➔ OT How did they fall / What were they doing at the time?: Any dizziness?: Blackout? (if yes, then must see Falls Clinic Dr):
Have you been able to get yourself up from the floor after having had a fall? No ☐ ➔ Therapist
Do you have a pendant alarm? Yes ☐ No ☐ ➔ Discuss Careline

Are you finding any daily activities more difficult to manage at home since your fall? If so, what?:	No ☐	Yes ☐ ➔ OT

Function & Equipment	**No**	**Yes**
Gait – Unsteady on feet / shuffles / uneven stride length	☐	☐ ➔ PT
Poor balance – needs to hold furniture / rails	☐	☐ ➔ PT
Timed Get up and Go **Time: secs** **The timed "Up and Go" is a test of basic functional mobility for frail elderly persons. It**		> 15 secs ➔ PT

measures, in seconds, the time taken by an individual to stand up from a standard arm chair (approximate seat height 46cm, arm height 65cm) walk a distance of 3 metres, turn, walk back to the chair and sit down again. The subject wears his / her regular footwear and uses their usual walking aid (none, stick, frame). No physical assistance is given.	

Walking aid checked?	Yes ☐ N/A ☐	
New walking aid required?	Yes ☐ No ☐	If yes refer to PT
Poor eyesight? Do test if possible Visual acuity: R…….. L………	Yes ☐ No ☐	If yes refer to Optician

High Risk Osteoporosis
Previous fragility # / On corticosteroids / BMI 19 or less No ☐ Yes ☐➔ **Dr (Falls Dr / GP)**
If yes, ?appropriate for hip protectors? No ☐ Yes ☐➔ **discuss / give information**

Mental Test Score						TOTAL /10		< 8 ➔ Falls Dr / GP	
Age	☐	Time to the nearest hour	☐	Recall' 42 West Street'	☐	Year	☐	Location	☐
Recognition of 2 people	☐	Yr of 2nd War (1939 - 1945)	☐	DOB	☐	Current monarch	☐	Count from 20-1	☐

Drug History
(Prescription only drugs are linked with falls - no need to ask of other medications)

1. If on 4 or more prescription only drugs - if Yes ☐ ➔ Refer to GP for medication review
2. If a fall is associated with any of the classes of prescription drugs below - if Yes ☐ ➔ Refer to GP for medication review
3. List medications and dosages:

Sleeping tablet ☐ Water tablet ☐ Heart tablet ☐ Antidepressant ☐ Blood Pressure Tablets ☐ Major Tranquillisers ☐

Observations

BP Lying, 10 mins (Pulse Norm: 60-100) (or 10mm with dizziness – see Dr)	**BP Standing, 2 mins** (Pulse Norm: 60-100) 30 sec | 60 sec | 90 sec | 120 sec Postural Hypotension: Fall of 20mm Hg systolic or 10mm with dizziness – See Dr	**BP Sitting, if BP can't be taken standing** (Pulse norm: 60-100)
Weight: Kg BMI: If BMI less than 19 – see Dr If unable to measure weight but patient has had unintentional weight loss then see Dr	**Height** (if unable to measure, e.g. curvature of spine/disabled, then double the demispan; sternal notch to end middle finger) ………..cm Height loss more than 2 inches? ☐ Yes	**Blood Glucose** (4-11 mmol) >11 and not known diabetic, refer to Dr

Outcome of Assessment

GP ☐ Comprehensive Geriatric Assessment ☐ PT ☐ OT ☐ Careline ☐ Falls Clinic Dr ☐
Discharge ☐ Information to Patient ☐

Comments………………………………………………………………………………………………

Name: **Signature:**

Designation: **Date:**