Chapter 25

Evaluating Telehealth Interventions

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25.1 Introduction

This chapter discusses an area viewed by many as a "special case" in eHealth evaluations: dealing with usage of *telehealth*, which is the delivery of healthcare services of a clinical nature where the provider of the service is remote in location and/or time from the recipient (such as teleconsultation, or teleradiology). We use the term *telehealth intervention* to indicate that our focus is on clinical processes (such as diagnosis or therapy) employing telehealth as a major component of their delivery. This term implies that the telehealth aspect is overlaid or inserted in a broader clinical activity or service, of which other components may be achieved by non-telehealth means.

Within the scope of our discussion, we also include evaluation of projects that establish and deploy these types of interventions, but not the evaluation of health services or systems as a whole, within which the interventions are delivered as one of a set of diverse and often complex interconnected components. This exclusion applies also to regional and national telehealth systems which serve multiple purposes and are therefore in the domain of health enterprise evaluation, rather than directly tractable by analysis methods intended for clinical services. An approach to such broader analysis is exemplified by work undertaken in Canada to develop a set of National Telehealth Outcome Indicators (Scott et al., 2007), which provided a base set of measurable indicators in the areas of quality, access, acceptability and costs, for post-implementation service-based evaluations. We also exclude the evaluation of underlying ICT-based mechanisms and infrastructure, including networks and systems that transmit and support telehealth such as broadband communications connectivity, and turnkey videoconferencing or store-and-forward systems, which are able to be

suitably evaluated by application of established technology or information systems analysis methods.

In the following sections we will first discuss how perspectives on telehealth can impact philosophically on evaluation approaches, imposing in some cases limitations and a narrowed view, which can discourage inclusion of a "full spectrum" of potential elements in evaluations. We will identify a wide range of approaches and associated elements that may be considered appropriate for telehealth evaluations, drawing predominantly from contributions in the clinical literature. Next we will link these elements with frameworks for evaluation that have been suggested by several authors, to demonstrate that the same elements may be viewed in different combinations and targeting different evaluation purposes. Finally, we will provide a commentary on practical constraints and considerations when conducting telehealth evaluations, and illustrate this with a case study based on a stand-alone intervention project.

25.2 Background

Early work in telehealth was poorly served by inadequate evaluation efforts. There are several reasons for this deficiency. Emphasis was often placed on the novelty of the technology or organizational aspects of the intervention, leading to evaluation of these aspects in preference to others more relevant to health impacts, and using associated evaluation methods which were often unfamiliar in clinical settings. A simplistic initial view of telehealth as the utilization of one of only a few different IT delivery mechanisms (such as video or image transfer), which could be analysed separately from any human or organizational aspects, reinforced this viewpoint. Health benefits and health economics gains are typically realized only after a lengthy period of time, beyond the extent of projects which delivered the intervention. Consequently, long-term clinical quality of care improvements and health services efficiency gains have often been regarded as impractical to evaluate. On the other hand, participant experience and satisfaction is relatively easy to assess, and so many early evaluations incorporated that as a significant component, a trend that has continued.

As noted by Bashshur, Shannon, and Sapci (2005), a dilemma exists as to whether to evaluate a telehealth intervention as if it were a typical health intervention coincidentally delivered by telehealth technology, or whether to treat it as a special type of intervention for the purpose of evaluation, because it relies on telehealth. A related issue arising is whether conventional evaluation methods for health interventions generally are applicable to telehealth interventions, as the first model above would imply, or whether specific evaluation methods should be developed for telehealth, in line with the second model. In reality, telehealth interventions are seldom evaluated without substantial interest in the telehealth aspects, so the second model has tended to dominate evaluation approaches. Consequently, evaluation methods designed for eHealth such as STARE-HI and GEP-HI in the clinical process arena, or for technology-based

health interventions more generally such as TAM and UTAUT in the user arena, are often deemed inadequate for telehealth interventions.

25.3 Telehealth Evaluation Approaches

Initial formal contributions in the field proposed flexible approaches concentrating on case-specific aspects of interest (Bashshur, 1995) or selective use of generic health services measures. For example, Hailey, Jacobs, Simpson, and Doze (1999) proposed that evaluation be performed across five areas: *specification, performance measures, outcomes, summary measures,* and *operational considerations*. *Cost* and *workload* aspects were identified as an important specific area, warranting careful development of appropriate analysis methods (Wootton & Hebert, 2001), and these have subsequently been a focus of many studies. Another important area targeted by many researchers was *psychosocial aspects* related to users (Stamm, Hudnall, & Perednia, 2000), such as usability and satisfaction. Emphasis was also placed on the efficacy of *diagnostic and management decisions* (Hersch et al., 2002) and associated impacts on *access* and *outcomes* in telehealth services (Hersch et al., 2006). Furthermore, *technical* aspects of implementations were also seen as a part of evaluation (Clarke & Thiyagarajan, 2008), in the areas of *information capture and display*, and *information transmission* (including statistical analysis and visual quality).

The notion of inferred *causality* linking the intervention characteristics with observed effects which were ascribed to telehealth in evaluations was described by Bashshur et al. (2005), and the influence of *medical care process models* for unifying the effects of client and provider behaviours and explaining participation effects and clinical outcomes was advocated by Heinzelmann, Williams, Lugn, and Kvedar (2005). These two alignments suggest that one strategy for conducting evaluations is to focus predominantly on the clinical aspects, which Brear (2006) has typified as determining *clinical benefits*, causal *influences* from *technical, people* and *organizational* factors, and *cost-effectiveness* in terms of obtaining the benefits (see Figure 25.1 below).

Alternatively, approaches to evaluation can be derived through synthesis, by identifying key groupings of evaluation elements from reviews of studies of a number of comparable interventions. Ekeland, Bowes, and Flottorp (2010) reviewed a wide range of studies offering evidence of clinical effectiveness and itemized major evaluation elements as *behavioural, cost/economic, health, organizational, perception/satisfaction, quality of life, safety, social,* and *technology*. Deshpande and colleagues (2009) reviewed store-and-forward interventions and summarized the main evaluation elements in four categories: *health outcomes, process of care, resource utilization* and *user satisfaction*. Wade, Kanon, Elshaug, and Hiller (2010) considered economic analyses of telehealth services, and determined that evaluation elements could be grouped as *costs and effects, technology*, and *organizational aspects*.

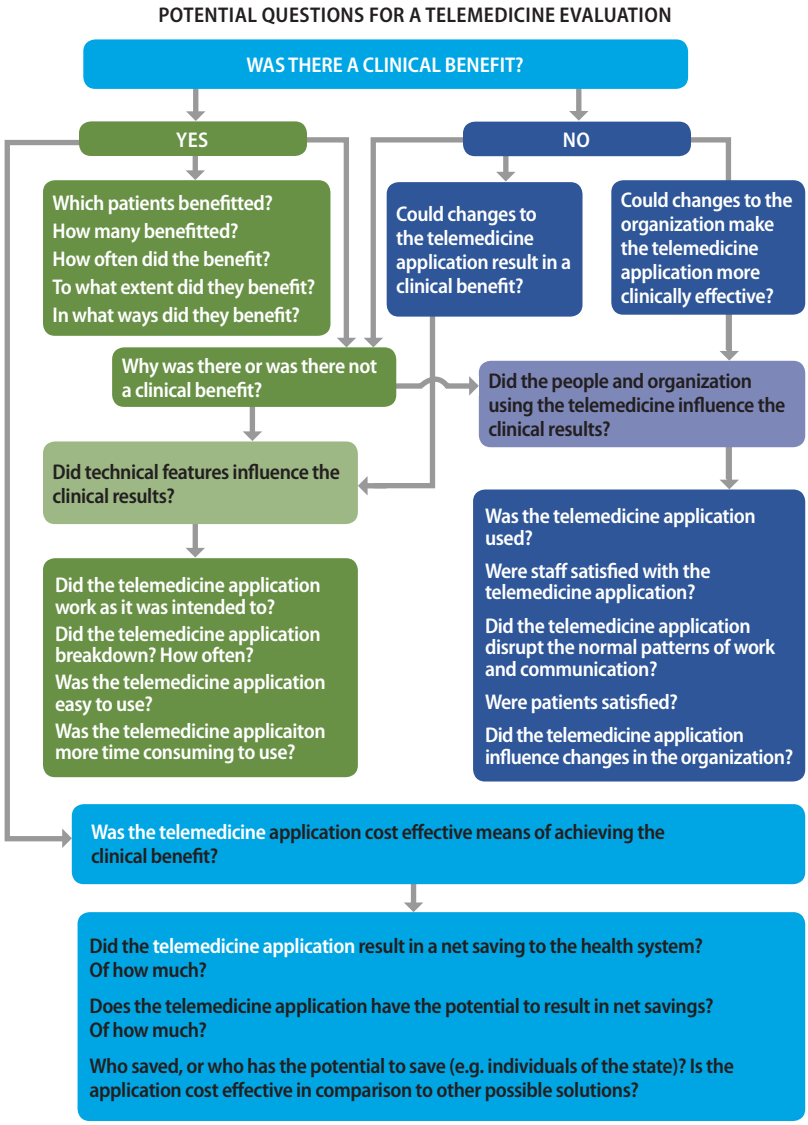

Figure 25.1. Clinically focused evaluation strategy.

Note. From "Evaluating telemedicine: lessons and challenges," by M. Brear, 2006, *The Health Information Management Journal* (Australia), *35*(2), p. 25. Copyright 2006 by SAGE Publications, Ltd. Reprinted with permission.

Recently a collaborative European proposal has been developed for a comprehensive Model for Assessment of Telemedicine Applications (MAST) (Kidholm

et al., 2012) which provides a wide scope of synthesis by addressing seven distinctive evaluation domains: *health problem and application, safety, clinical effectiveness, patient perspectives, economic approach, organizational aspects*, and *socio-cultural/ethical/legal aspects*. It is recommended that these be analysed in a three-step approach, covering *preceding considerations, multidisciplinary assessment*, and *transferability assessment*. This possibly is the most extensive example of a synthesis approach and has yet to see widespread adoption.

25.3.1 Telehealth Evaluation Frameworks

Evaluation frameworks have been developed to provide a higher-level contextual setting for selection, or aggregation, of the above diverse elements. An evaluation framework consists of categories containing different evaluation questions or objectives, from which an evaluator might choose those most pertinent to the intervention. A strong argument in favour of framework approaches is that ad hoc choices of evaluation elements can lead to selection (or, alternatively, omission) of measures which are strongly correlated with the success (or failure) of interventions (Jackson & McClean, 2012).

Some early framework concepts followed a sequential set of considerations related to the telehealth intervention: Hebert (2001) proposed three areas of focus for evaluation: *structure*, *process* and *outcomes*. Bashshur et al. (2005) advocated a refined version of this approach with high level sequential structuring of evaluation aspects in four time steps: *evaluability assessment* to identify what could or could not be evaluated based on the description and scope of the intervention project; *documentation evaluation* (including artefacts such as software) for the intervention design and implementation; then applying *formative or process evaluation* for the change and acceptance associated with deployment of the intervention in a clinical service; and finally *summative or outcome evaluation* applicable to health and economic benefits.

Taxonomies of telehealth are useful for identifying and grouping elements, which may be candidates for evaluation, in different circumstances. Tulu, Chatterjee, and Maheshwari (2007) defined a structural taxonomy based on the components that must be used in the realization of a service, namely *application purpose, application area, environmental setting, communication infrastructure*, and *delivery options*. More recently, Bashshur, Shannon, Krupinski, and Grigsby (2011) advanced a more top-down approach via conceptualization as a three dimensional space describing intersection sets of *functionality, application* and *technology* elements (see Figure 25.2). Nepal, Li, Jang-Jaccard, and Alem (2014) proposed a framework of broader coverage, including six aspects for evaluation: *health domains, health services, delivery technologies, communication infrastructure, environment setting*, and *socio-economic analysis*.

Alternative approaches to evaluation frameworks have emerged recently in an attempt to provide greater inclusivity and flexibility, as those described above tend to focus on abstract concepts to define them. Van Dyk (2014) reviewed possible areas for evaluation based on technology development models, and

proposed a multi-dimensional space associated with *technology maturity* principles and *systems life cycle* concepts. A hybrid approach was proposed by Maeder, Gray, Borda, Poultney, and Basilakis (2015) as a means of aligning evaluation with *organizational learning models* and *health system performance indicators*. Such frameworks as these offer comprehensive coverage and useful mechanisms for describing evaluation instances (especially those pertinent to large-scale projects or services), but add conceptual complexity that cannot be easily navigated for simpler telehealth implementations.

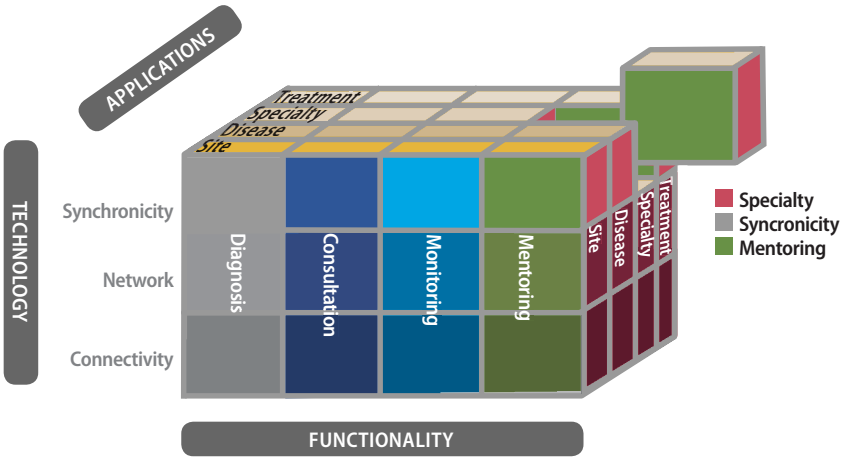

Figure 25.2. Top-down taxonomy.

Note. From "The taxonomy of telemedicine," by R. Bashshur, G. Shannon, E. Krupinski, and J. Grigsby, 2011, *Telemedicine and e-Health, 17*(6), p. 491. Copyright 2011 by Mary Ann Liebert, Inc. Publishers.

25.3.2 Telehealth Evaluation Practice

The lack of consensus on evaluation methodologies for telehealth is largely a consequence of the complexity of telehealth interventions. Many of the frameworks discussed so far represent attempts to map this complexity onto evaluation methodologies, whose aim is to measure the impact and efficacy of a telehealth intervention. The "gold standard" in the evaluation of medical interventions is the randomized controlled trial (RCT), which tends to be applied to an intervention as a self-standing analysis, without catering for the effects of contextual complexity.

There are many reasons why such a trial is not usually feasible in telehealth (Agboola, Hale, Masters, Kvedar, & Jethwani, 2014), including the inability to conceal from participants the assignment of subjects into control or intervention groups. The complexity and expense of RCTs limits their application to small, short-term projects. There is also an ethical issue of denying control groups access to apparently beneficial technologies, when the aim of the evaluation might be to assess the cost-effectiveness of an intervention whose clinical benefit might not be in dispute (Bonell, Fletcher, Morton, Lorenc, & Moore,

2012). Furthermore, there is a need in telehealth evaluations to investigate not only the change in clinical outcomes, but also the mechanisms underlying such changes. Such mechanisms should ideally be studied individually, as well as through their combined impacts on clinical outcomes. RCTs are not capable of such things as assessing the separate effects of intervention components or of discovering hidden explanations for the success or otherwise of interventions (Marchal et al., 2013).

A major telehealth evaluation exercise using cluster randomized trial methodology was conducted as part of the United Kingdom-based Whole Systems Demonstrator (WSD) project, seeking to validate the effects of home telecare on a range of clinical aspects including mortality, hospital admissions, use of care, quality of life, etc. (Steventon, Bardsley, & Billings, 2012). This provides a good example of the pros and cons of the randomized trial approach. While a high strength of evidence was obtained by sample sizes in the range of thousands, many of the findings did not show major gains for telehealth and it has been suggested that such large-scale trials may be subject to systematic bias due to their health system context (Greenhalgh, 2012).

A feature of RCTs is the separation of experimenters and participants; a double-blind trial is administered by clinicians who are unaware of which group (control or intervention) subjects belong to. As pointed out above, such methodologies produce rigorous verifiable measures, but might not capture the benefits and mechanisms of complex medical interventions such as telehealth. A growing trend is to reduce the isolation of researchers and subjects, with benefits to both assessing the benefits of interventions, and to more widespread implementation of such interventions. For example, in a wide-ranging review of participatory research by Jagosh and colleagues (2012), it was concluded that "multi-stakeholder co-governance can be beneficial to research contexts, processes, and outcomes in both intended and unintended ways".

It is clear from the preceding that telehealth is among the more complex medical interventions and, accordingly, evaluation of telehealth systems cannot adopt methodologies that might be appropriate for, say, a pharmaceutical trial. Increasingly, telehealth projects are assessed by methods in which a large number of stakeholders contribute to the process, and the underlying research questions go beyond simple measures of clinical effectiveness. It has been noted (Gagnon & Scott, 2005) that telehealth evaluation often serves different purposes for different stakeholders, so it might be expected that no single evaluation framework or methodology can cater comprehensively for it.

This complex environment may be best approached by a participatory strategy for evaluation, involving stakeholders in study designs. Translation of evaluation findings and evidence to influence policy is a further challenge, as policy-makers are typically difficult to engage as stakeholders in long-term studies; nevertheless, the power of case studies to connect back to them has been demonstrated (e.g., Jennett et al., 2004). The question of responsiveness and insight by policy-makers in response to the provision of evaluation findings and

evidence has been raised (Doarn et al., 2014) and it is argued that policy formulation might be included as a stage of any overall evaluation.

25.4 Case Study: Evaluation Using Participatory Principles

Chang (2015) identified five stages in the cycle of telehealth implementation: *inputs, activities, outputs, outcomes* and *impact*. However, in practical telehealth implementations, the early stages of the project (system design, stakeholder analysis) are often separated from other processes, mainly through such restraints as the need to use off-the-shelf hardware, or interoperability issues outside the scope of the project, or the difficulty of involving all stakeholders in the study. In cases where participants are able to contribute to technology design, such participatory methods have been shown to contribute to the success of telehealth systems (Li et al., 2006).

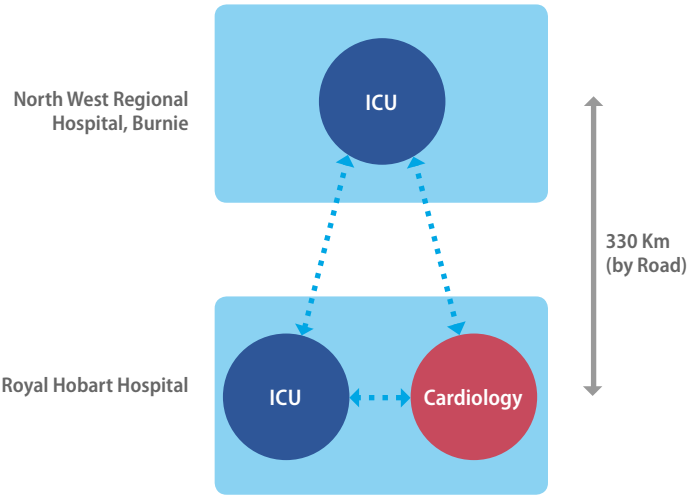

Figure 25.3. Telehealth connectivity for the case study project.

Note. From "Applying an integrated approach to the design, implementation and evaluation of a telemedicine system," by S. Hansen, L. Wilson, and T. Robertson, 2013, *Journal of the International Society for Telemedicine and eHealth, 1*(1), p. 21. Copyright 2013 by ISFTEH. CC BY License.

An example of a telehealth implementation, which incorporates aspects of participatory design and participatory research/evaluation, was the ECHONET project in Australia described by Hansen, Wilson, and Robertson (2013). Its principal aim was to support the Intensive Care Unit of North West Regional Hospital (NWRH) located in Burnie, North Western Tasmania. This ICU had basic intensivist coverage, but relied on other hospitals, and predominantly a major tertiary hospital Royal Hobart Hospital (RHH), for support in other specialist services, notably bedside echocardiography (see Figure 25.3). In this project, three mobile

multichannel broadband telemedicine units connected, over a broadband network, the ICU of NWRH with separate nodes in two departments (Cardiology and ICU) of RHH. The aim was not to provide a fully outsourced intensivist service, the suggested model for some recent eICU implementations (Goran, 2012), but to provide support for the small, isolated specialist staff at NWRH.

A combination of a participatory research philosophy and learnings from the team's previous experience with telemedicine systems (Wilson, Stevenson, & Cregan, 2009) influenced the approach. It was agreed from the beginning that an integrated design, implementation and evaluation approach would be adopted. Underpinning the practice of participatory research is an intention of the researcher to effect positive change on the situation within which the research is taking place while simultaneously conducting research, and a collaborative approach between the researcher and subject in reaching this objective and developing understanding.

Activities were carried out in the ECHONET project that informed the design of the system, the implementation strategy adopted, and the criteria assessed in the evaluation. These activities consisted of *stakeholder interviews*, *baseline study*, *design workshops,* and activities relating directly to the clinical trial of ECHONET including *interviews, questionnaires* and *logbooks*. In detail, these activities were as follows:

- The stakeholder interviews helped to establish the success criteria by which the system was assessed in the evaluation phase. They also served to inform the design workshops by establishing potential applications outside the design brief.

- The baseline study provided a datum on which changes might be captured as a result of the implementation and provided the project team with an understanding of the context and environment in which ECHONET would be used, including clinicians' existing work practices.

- Several design workshops were carried out with mock-ups of the graphical user interface (GUI) and as early prototypes became available, enabling the project to capture the benefits of user-centred design as described by Sutcliffe et al. (2010).

- Instruments deployed during the trial included weekly interviews with all users, logbooks, and a series of mid-trial interviews to monitor the trial for possible modifications, and to refine the end-of-trial processes. Post-trial instruments consisted of interviews with participants, a questionnaire for all participants and an analysis of the nature and frequency of all system activations.

These activities resulted in a list of success criteria, against which the success of the trial could be assessed, and were grouped under four broad categories of technical success, clinical efficacy, cost-benefit, and social/organizational. These criteria, described in detail by Hansen et al. (2013), differed markedly from those envisaged before the interactive process described above, and formed the basis of the final evaluation. While improved clinical outcomes are usually regarded as the primary benefit of telemedicine systems, in this case clinically driven activations of the system proved to be a relatively minor application, and the trial yielded too few such activations in any particular clinical category to achieve statistical significance. The way in which the success criteria were themselves outcomes of the combined process is shown in Figure 25.4, in which the vertical axis represents approximately a time axis.

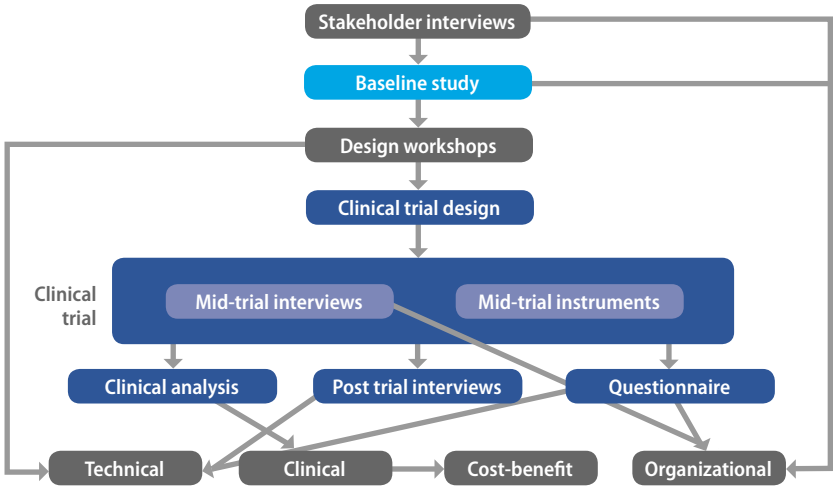

Figure 25.4. Components of the ECHONET project.

Note. From "Applying an integrated approach to the design, implementation and evaluation of a telemedicine system," by S. Hansen, L. Wilson, and T. Robertson, 2013, *Journal of the International Society for Telemedicine and eHealth, 1*(1), p. 27. Copyright 2013 by ISFTEH. CC BY License.

The success criteria and the measurable outcomes have been tabulated in Table 25.1. They are grouped as relating to the four broad categories of usability/technical, clinical, cost/benefit and organizational. Clinical benefits were difficult to quantify due to the diversity of clinical applications, but the validity of the technical solution was verified, and a range of social/organizational benefits were demonstrated, mainly among improved collegiate and educational interactions among the three participating sites.

It is clear from Table 25.1 that most of the perceived benefits were in the social/organizational area. However, the principal outcome of the project was a verification of the methodology of integrating design, implementation and eval-

uation processes. Many of the benefits were not envisaged at the beginning of the project, and the adaptive nature of the evaluation process ensured that these benefits could be assessed.

Table 25.1
Success Criteria for the ECHONET Project, Grouped Under Four Broad Evaluation Categories

Evaluation domain	Usability and technical	Clinical	Cost/benefit	Social/organizational
Success criteria (Evaluation criteria shaded)	Few faults	Reduced transfers		• Clinically safe; no adverse outcomes
	In routine use	More timely diagnosis	Continuing use following trial/clinical sustainable	• Number of bedside consults and number of participants
	Ease of use measured by number of users	Reduced travel for family and outpatients	Financially sustainable after trial	• Raising knowledge and skills (e.g., benchmarking ICU procedures at NWRH)
			Cost/benefit analysis based on other criteria outcomes	• Improved contact between ICUs (e.g., NWRH postings more popular) • Accepted as part of normal workflow (e.g., post-trial activations) • Strengthen ICUs (e.g., long-term benchmarking)

The most significant outcomes centred around improved collegiate relationships and educational opportunities among the users. Participants, in both the interviews and questionnaires, were very positive about the usability and usefulness of ECHONET, with some minor technical reservations. While all participants agreed that there were strong clinical benefits, the data sample was too small and diverse for this to be quantified by this study.

While the benefits of the collaboration supported by ECHONET for clinicians in the more remote hospital site at NWRH were more obvious and expected, clinicians in Hobart also recognized they had benefited from the collaborations made possible by the new technology. The educational benefits of ECHONET were realized early in the clinical trial. Education represents a good area in which to start using new telemedicine systems as sessions can be scheduled to allow familiarization with the system in a relatively low-pressure situation and routine use. The potential for ECHONET to be used for this purpose emerged early and strongly during the baseline study and this potential was confirmed and further explored during the clinical trial by clinicians at both hospitals.

25.5 Summary

This chapter has presented a view that Telehealth may be regarded as a "special case" in eHealth evaluation, in that it difficult to treat its components in isola-

tion from the context of usage. Nevertheless, typical telehealth evaluations tend to have focused on selected areas which include costs and resources, organizational and social aspects, and clinical benefits, rather than comprehensive coverage. Attempts to identify various sets of criteria, models and frameworks for evaluation have been described in the literature without achieving widespread consensus. These have been based around such disparate views as the inherent sequential characterization of a Telehealth intervention over time, or the taxonomic analysis of Telehealth along system functionality lines. It is argued that there is an overarching need to take a holistic approach and integrate different elements of evaluation to understand characteristics of the overall system of interest which is enabled by Telehealth. A case study has been presented to illustrate this process, borrowing from the central paradigm of participatory research as the holistic mechanism. This example was not intended to be definitive or exclude other approaches, but to emphasize the power of multifactor evaluations in such settings.

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