MEDINFO 2001
V. Patel et al. (Eds)
Amsterdam: IOS Press

Telehealth Success: Evaluation Framework Development

Marilynne Hebert

Health Telematics Unit, Department of Community Health Sciences, University of Calgary, Canada

Abstract

Implementing telehealth applications represents a substantial investment of resources, which is one reason why success is of great interest. Many research and evaluation studies have investigated measures of successful telehealth systems. However, the term "telehealth" represents a wide range of variables including clinical application, characteristics of the information being transmitted, temporal relationships of data transfer and the organizational context. These sources of variability pose many challenges for evaluation as well as for building a cumulative history of research.

A conceptual framework is required that assists in categorizing results and drawing conclusions based on an accumulation of findings. One measure of "success" in health care is quality patient care and this reflects a primary reason for ICT investments. For this reason, Donabedian's work in evaluating quality provides the basis for the proposed framework. DeLone & McLean's definitions of IS success assist in conceptualizing Donabedian's structure-outcome-process variables in a telehealth context.

Multiple evaluation approaches have been used to address different types of questions. Prior to the technologies being introduced to clinical care, there are usually many studies to demonstrate their effectiveness. Health Technology Assessment examines a broader context than the technology alone, including costs and comparing alternatives that would exist in the absence of telehealth. It considers performance measures; outcomes; summary measures, operational considerations, and other issues. Program Evaluation examines use of the technology to provide a service or deliver a program. Evaluation questions often address whether the program goals have been met and if it is operating as expected.

Perhaps of greater concern than the evaluation approach taken is generalizability of findings. Recent studies have given inadequate attention to defining what is done (i.e. comparison of telehealth to most appropriate alternative), identifying the beneficiaries of telehealth (i.e. ensuring randomly selected participants take part) and what is measured (i.e. including benefits, drawbacks and side effects of telehealth).

Evaluation efforts and frameworks have identified "success" factors such as technical acceptability of the system, cost/benefit/effectiveness, organizational support, satisfaction, recruitment and retention, client outcomes such as quality of life, acceptance by consumers and providers.

Less is known about the relationship among these variables and whether the findings around one variable are generalizable to other settings or applications. For example, organizational support may be essential for successful provider-patient interactions via videoconference, which result in higher quality of life. A conceptual framework would assist in accumulating this type of evidence and supporting more advanced research efforts.

Keywords:

Health Care Quality, Access, and Evaluation; Telemedicine

Introduction

The term "telehealth" is used to describe the exchange of health information and provide health care services through electronic information and communications technology (ICT), where participants are separated by geographic, time, social and cultural barriers [1,2]. Variations included under this term are defined by clinical application (e.g. tele-psychiatry, tele-radiology), characteristics of information being transmitted (e.g. audio, visual, text and data) and temporal relationships (e.g. synchronous – real time and asynchronous – store and forward).

Context of the applications – technically, organizationally and individually - also contribute to the complexity of defining a successful system or program. This number of potential variables under the umbrella of telehealth poses many challenges for evaluation and building a cumulative history of research.

Materials and Methods

Framework Development

In health care, investments in ICT are expected to positively affect patient care, so an evaluation of ICT success would be expected to include this element. Donabedian's [3] model for assessing Quality of Care is well known and has been used for many aspects of health care. In this model the overall dependent variable is quality of care. It includes three sub-categories of variables: structure, process and outcome. **Structure** includes the human, physical and financial resources (i.e. inputs) that are needed to provide health care. Structure is an indirect measure of the quality of health care, more an antecedent than outcome, in the sense that a better structure improves the changes of providing good health care. **Process of care** is the set of activities that goes on between practitioners and patients. The characteristics of this process have a direct influence on the health of patients. **Outcome** is the change in patient's current and future health status that can be attributed to the preceding health care.

An important underlying premise in Donabedian's framework is that the relationship between structure and process or process and outcome must be understood before changes in one will result in the expected changes in the other.

In the Management Information Systems (MIS) field DeLone & McLean [4] were faced with a similar dilemma in attempting to identify and categorize the dependent variables researchers were using to determine information systems' success. From their review of 180 MIS studies, they identified 6 variables used to measure success, including System Quality, Information Quality, System Use, User Satisfaction, Organizational Impact and Individual Impact. From the research they also demonstrated an empirical relationship among the variables (Figure 1).

DeLone & McLean's work in identifying MIS success measures assists in conceptualizing the structure-process-outcome variables in a telehealth context as well as contributes to developing a framework useful for accumulating results. Similarities in the frameworks contribute to this convergence:

- Structure – information quality, system quality
- Process – system use, user satisfaction
- Outcome – individual and organizational impact.

DeLone & McLean [5] explicitly identify the relationships among the 6 variables. Similarly, in Donabedian's model, there are distinct relationships among the variables: Structure affects process and process affects outcomes.

Current Evaluation Approaches

Health technology assessment (HTA), cost-benefit analysis and program evaluation have figured prominently in telehealth evaluation, each making contributions through addressing different questions. The role each plays is explored in more detail as well as how they may continue to contribute to an overall evaluation framework.

Understanding effectiveness of the technology itself - whether the technology works as it is expected to - is an important early aspect of evaluation. Taylor [6] surveyed published work in telehealth and found the studies were divided into two areas: technical and service. The focus of studies on *Telemedicine Systems* included equipment capability, requirements, safety and efficacy. The majority of studies assessed accuracy of diagnostic decisions made from digital images displayed on computer such as radiological images, pathology slides and dermatological lesions.

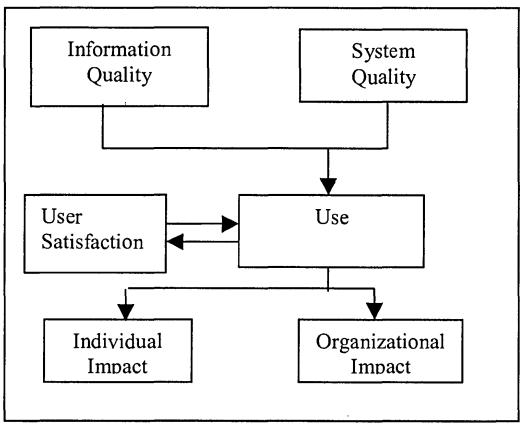

Figure 1 – DeLone & McLean's Dimensions of IS Success

Health Technology Assessment (HTA) goes one step further and asks not only if the technology works, but at what cost and whether it is a good replacement for current practice. It does this by comparing telehealth to alternatives that would exist in the absence of telehealth. Ohinmaa, et. al. [7] note that HTA takes a broad view of a particular technology and synthesizes different types of information to provide a detailed description. This analysis considers a number of elements: specification; performance measures (time, quality, cost); outcomes (safety, efficacy, effectiveness); summary measures (cost comparisons); operational considerations (access, acceptability); and other issues (confidentiality, legal). While Randomized Control Trials provide the strongest evidence in comparing new and conventional treatments, often small sample sizes for telehealth projects mean randomization is not possible. Another difficulty is using data collected during pilot studies because it may not be comparable to services in full operation. Information from a HTA can be used to help decide whether technology should be adopted, and if so in what ways.

Program evaluation examines use of the technology to provide a service or deliver a program. The evaluation questions often address whether the program goals have been met and it is operating as expected. *Telemedicine*

Services were the focus of the second set of studies reviewed by Taylor, which included effectiveness of care delivery and value of health care delivered via telemedicine.[8]

He noted evaluation questions around services must take into account the stage of the implementation life cycle (feasibility study, pilot/project, implementation/program, effects) because evaluation questions guide decision-making differently in each phase and the choice of outcome measures depends on aims of the telehealth service. Outcome measures also reflect the intent of the service, e.g. diagnosis, treatment, follow-up or education. Comparability of results depends on these variables being explicitly stated.

Perhaps of greater concern than the evaluation approach taken is generalizability of the findings. Wyatt [9] notes that even though telemedicine is feasible and increasingly easy to use, it remains unclear whether it is necessary or beneficial for patients, doctors or the health service. Randomized trials of telemedicine were first performed two decades ago, but more recent studies seem to have been driven by technology push rather than clinical pull [10, 11]. These studies give inadequate attention to three fundamental aspects of any trial: defining what is done, to whom it is done, and what is measured [12]. In *defining what is done*, demonstrating the benefits of telehealth must include a comparison of the electronic means for transferring information with the most appropriate alternative in order to identify the unique effects of using the technology [13]. For example, this may mean comparing tele-dermatology with a telephone consultation that includes mailed photographs.

In identifying the beneficiaries of telehealth (*to whom it is done*), caution should be exercised in generalizing from studies that rely on volunteers or enthusiasts. To determine the general benefit of telehealth requires randomly selected participants, both doctors and patients.

The benefits, drawbacks and side effects of telehealth (*what is measured)* should be determined as well as their relationship to the care process, compared to what occurs in traditional care processes. For example, information exchanged during a consultation between specialist and patient affects patient participation in decisions, satisfaction and compliance with treatment regime. The ways this may be changed through telehealth consultations needs to be examined.

Results

Case Studies

Examination of case studies illustrating telehealth evaluation is a useful exercise to initially explore the framework's utility. Case studies also provide a vehicle to ask the questions posed by Wyatt as well as examine relationships between structure and process and process and outcome. The following two studies provide examples for consideration.

Case Study A

Flatley-Brennan [14] conducted a randomized field investigation that demonstrated the use and effects of a specialized computer network, the ComputerLink, among persons living with AIDS (PLWA). The study purpose was to determine the acceptability of an internet-based health care application and the likely outcomes resulting from its use. They wanted to determine whether a home-based computer network designed for PLWA would be used and whether it would reduce social isolation, improve confidence and skill in decision-making without causing a differential decline in health status.

Study results indicated use of the system reduced social isolation through peer contact (once participants' levels of depression were controlled for) and improved decision-making confidence as a function of the number of times the system was accessed. Flatley-Brennan concluded that computer networks provide feasible alternatives for the delivery of health services to homebound individuals.

In this case changes were made in structure, process and outcome compared to traditional care (Table 2). It illustrates a direct link between a change in structure and the care process and through that, client outcomes. The distinct difference in process compared to traditional care is the more involved role of the consumer in the care process.

The evaluation framework can assist in identifying study characteristics that make it generalizable to other groups of PLWA or generally to homebound individuals. For example, there may be additional questions about specific characteristics of the technology that made it successful (e.g. ease of use, location of the equipment) as well as the individual user.

Case Study B

It is accepted that "sustained improvement in blood glucose control is the only treatment outcome which will reduce or eliminate the long term complications of diabetes mellitus" [15]. Albisser et al. [16] designed and evaluated an information system to facilitate this task. The system is voice-interactive, physician directed and provides remote patients 24-hour access via touch-tone telephone. Patients access the system each day to report self-measured blood glucose levels or hypoglycemic symptoms together with dietary changes, planned exercise, stress, illness or other lifestyle events. They receive immediate advice with respect to medication dosing changes, and other pertinent feedback. Outcomes included better diabetes management as measured by reduced glycated haemoglobin and diabetic crises.

This study provides another good example of changes in structure (e.g. the telephone reporting system) directly affecting the process of care (e.g. immediate reporting and feedback on diabetic data) and subsequent patient outcomes (e.g. crisis prevention and blood glucose maintenance). It reflects a more traditional model of care where the physician manages the care process and outcome measures are medical in nature. The evaluation framework can assist in identifying study characteristics that make it

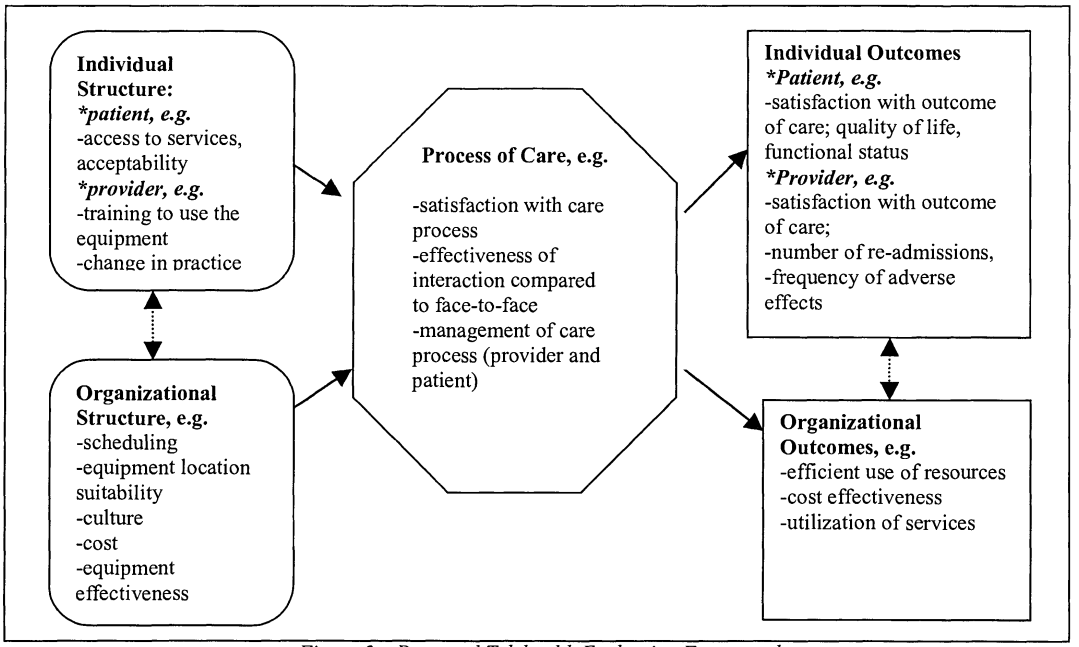

Figure 2 – Proposed Telehealth Evaluation Framework

generalizable to other diabetic or chronically ill populations.

Discussion

A proposed telehealth evaluation framework (Figure 2) expands Donabedian's original framework to explicitly separate the structural and outcome variables into individual and organizational. In this way all similar studies (e.g. diabetic homecare) can be examined using the framework to extract commonalities and differences. This will be helpful to begin drawing conclusions about where telehealth is effective as well as what variables demonstrate "success" (e.g. satisfaction) and begin investigating other issues.

This framework is intended to begin developing a body of knowledge around telehealth evaluation. Donabedian's model is useful to identify influential relationships among the success variables defined for telehealth. Some studies report on all 3 of these variables - structure-process-outcome. For example, the Pediatric Tele-Homecare project [17] included measures for families, clinicians and health service agencies in each of the variables.

What is less clear in many studies is the direct relationship among the categories or generalizability of the findings. The following three questions illustrate an evaluation strategy:

1. When introducing telehealth technology, what are the expected relationships among structure-process-outcome? What can be made explicit and what is implied?
2. How does using the technology compare to the process of traditional care?
3. Are the outcomes of using the technology understood for clients, providers and organizations?

Table 2 –Case Study Summary

Cases	Quality of Care Factors		
	Structure	**Process**	**Outcome**
A. Home-based computer network	-installation of a specialized computer network -training	-improved decision-making confidence	-reduced social isolation -measured by increased peer contact
B. Diabetic monitoring via telephone	-supports communication of data -safety and efficacy of equipment	-regular reporting of data -immediate feedback	-better diabetes management -reduced diabetic crises and glycated hemoglobin

Conclusion

The evaluation framework is being tested through mapping of project reports identified in a literature review as well as contacting sites that did not publish their results. Several quasi-experimental studies in tele-homecare are expected to report their findings using this framework.

References

[1] Field, M. (Ed.) *Telemedicine: A Guide to Assessing Telecommunications in Health Care.* Washington, D.C. National Academy Press, 1996.

[2] Reid, J. *A Telemedicine Primer: Understanding the Issues.* Billings, Montana; Artcraft Printers, 1996.

[3] Donabedian, A. *Explorations in Quality Assessment and Monitoring. Volume 1: The Definition of Quality and Approaches to its Assessment.* Ann Arbor, Michigan; Health Administration Press, 1980.

[4] Delone, W.H. & McLean, E.R. Information systems success: the quest for the dependent variable. *Information Systems Research*, 1992: 3(1): pp. 60-95.

[5] Ibid DeLone & McLean, 1992.

[6] Taylor, P. A survey of research in telemedicine: Telemedicine systems. *Journal of Telemedicine and Telecare* 1998: 4(1); pp. 1-17.

[7] Ohinmaa A, Reponen J. A model for the assessment of telemedicine and a plan for testing of the model within five specialities. Finnish Office for Health Care Technology Assessment (FinOHTA Report No.5), 1996.

[8] Taylor, P. A survey of research in telemedicine: Telemedicine services. *Journal of Telemedicine and Telecare* 1998: 4(2); pp. 63-71.

[9] Wyatt, J.C. Hospital information management the need for clinical leadership. *BMJ* 1995: 311 (6998); pp. 175-8.

[10] Wyatt, J.C. Can telemedicine be used to improve communication between primary and secondary care? Commentary: Telemedicine trials - clinical pull or technology push? *BMJ* 1996: 313 (7069); 1380-1.

[11] Maclaren, P. & Ball, C.J. (1995). Telemedicine: lessons remain unheeded. *BMJ,* 310 (6991); pp. 1390-1391.

[12] Friedman, C. & Wyatt, J. *Evaluation Methods in Medical Informatics.* New York: Springer-Verlag, 1996; p. 9.

[13] Ibid. Field, M., 1996.

[14] Flatley-Brennan, P. Computer network home care demonstration: A randomized trial in persons living with AIDS. *Computers in Biology & Medicine* 1998: 28(5); pp. 489-508.

[15] Albisser, AM, Harris, RI, Sakkal, S., Parson, ID, Chao, SC. Diabetes intervention in the information age. *Medical Informatics* 1996: 21(4); pp. 297-316.

[16] Ibid. Albisser, AM, et al., 1996.

[17] Dick, P. & Young, N. Methodological issues in clinical evaluation of telehealth applications: The example of tele-homecare. Presentation to the *Telehealth Research Summer Institute*; Health Telematics Unit, University of Calgary; July 2000.

Address for correspondence

Marilynne Hebert, PhD
Health Telematics Unit
University of Calgary
G204 Health Sciences Centre
3330 Hospital Drive N.W.
Calgary, Alberta CANADA T2N 4N1