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Evaluating telemedicine: A focus on patient pathways

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Evaluations of telemedicine have sought to assess various measures of effectiveness (e.g., diagnostic accuracy), efficiency (e.g., cost), and engagement (e.g., patient satisfaction) to determine its success. Few studies, however, have looked at evaluating the organizational impact of telemedicine, which involves technology and process changes that affect the way that it is used and accepted by patients and clinicians alike. This study reviews and discusses the conceptual issues in telemedicine research and proposes a fresh approach for evaluating telemedicine. First, we advance a patient pathway perspective, as most of the existing studies view telemedicine as a support to a singular rather than multiple aspects of a health care process. Second, to conceptualize patient pathways and understand how telemedicine impacts upon them, we propose simulation as a tool to enhance understanding of the traditional and telemedicine patient pathway.

Keywords: Clinical pathways, Computer simulation, Evaluation, Telemedicine, Patients

The telemedicine evaluation literature has grown substantially from the advancement of a specific framework for assessing telemedicine by the Institute of Medicine (IOM) (16). This early report identified five dimensions important to evaluating telemedicine: quality, access, cost, patient perceptions, and clinician perceptions. However, a more recent report by The Lewin Group (27) both confirmed and extended these evaluation dimensions. It considered the properties of these dimensions, in terms of measures and their impacts, but also the methodology issues involved in evaluation. This directly responded to some disquiet expressed in the literature over rigor and consistency that limited the generalizability of some studies' findings. In light of these concerns, we discuss two possible improvements for telemedicine evaluation.

First, we argue that the focus of the evaluation itself should be widened to look at telemedicine in the context of the patient pathway (also known in the literature as the clinical pathway) to understand its place along the patient's journey through the health service. Second, we put forward simulation as a tool for evaluating telemedicine through its representation of the patient pathway. Simulation will be discussed as a viable methodology for addressing some of the weaknesses documented in telemedicine evaluation, through a review of the measures and methodologies used in the assessment of telemedicine. The discussion of the potential benefits of simulating patient pathways is supported by an illustration—using leg ulcer sufferers as a case example—to contribute to an understanding of care delivery by traditional and telemedicine processes.

TELEMEDICINE EVALUATION ISSUES

Measures

Reviews of telemedicine evaluation are limited (1;12;25;27), but those that do exist provide important overviews as to the status of evaluations in terms of the measures and methodology used to assess telemedicine. Most evaluations have sought to assess various quantitative measures of effectiveness (e.g., diagnostic accuracy), efficiency (e.g., cost), and engagement (e.g., patient satisfaction) to determine its success. However, these studies have tended to focus on single clinical contexts, specialties, and measures. To highlight the problematic issues around the measures currently assessed in telemedicine evaluation, we will briefly focus on three key evaluation measures: (i) *Diagnostic accuracy*—this measure has tended to overly dominate many studies' outcomes (1); (ii) *Cost* (and its associated variables, e.g., benefit, utility, and so on)—many studies have equated a cost-saving as a benefit, but with no reference to how it affects clinical outcomes (28); and (iii) *Patient satisfaction*—this measure is the

Table 1. Key Evaluation Methodology Issues for Telemedicine

Evaluation methodology issue	Methodological Approach	
	Current telemedicine evaluations	Simulation
Technological maturity		
Progress of technology through its lifecycle and the stage of evaluation	Often carried out as single case studies of performance at too early or late a stage and can often produce unduly positive or negative findings (26)	Evaluates telemedicine along the continuum of maturity from immature prototypes to fully matured working systems
Focus of evaluation		
Scope of the evaluation from the technology itself to its broader context	The focus is predominantly placed on the specifics of the technology itself, as opposed to its organizational impact (2).	Offers a more holistic approach, in analysing the processes of care into which telemedicine is situated, along with key evaluation measures
Perspective of evaluation		
Standpoint from which the benefits of the technology are realized	A single perspective analysis is most common, often to the point of exclusion of the impact from an alternative perspective (21)	Provides a multi-perspective analysis, (depending on the model's variables), e.g., to reflect a patient/clinician view
Comparator		
Definition of a suitable control group with which to gauge the effect of the technology's intervention	Patients who are treated with and without telemedicine and then compared, are often not of a similar level (8)	Allows a consistent way of performing like-with-like comparisons as data from a single set of patients can be run in both the traditional and telemedicine models
Randomization		
Assigning of participants to experimental and control groups on a random basis	This process is difficult to achieve as the sample group in a study are generally quite small, in some published cases as few as ten patients (20)	Avoids randomization issues because a single set of patients can be run in both the traditional and telemedicine models
Time horizon		
Duration of data collection in a study	The focus has been on short-term pilot projects, with a lack of follow-up (5)	Predicts future outcomes, applying the analysis to gauge the long-term effects of telemedicine implementation

most common evaluation undertaken, tends to produce consistently positive results, but can often be misleading, as patient satisfaction measures often fail to go beyond first impressions (19).

A major reason for some of the limitations cited in the research is that few high-quality studies exist (15). Despite the usefulness of the clinical and economic data that have been produced, the methodological paucity in the research has somewhat undermined the value of the assessments undertaken. This finding has resulted in calls for patients and practitioners alike to remain skeptical over the professed benefits of telemedicine compared with traditional face-to-face patient care (12). In an attempt to manage some of the methodological issues in telemedicine evaluation, simulation is proposed as a potentially useful tool for producing more robust findings.

Methodology

As a methodological approach, simulation revolves around creating computer models of social structures and processes. These models are subject to "simulation" that is experimentation through the manipulation of variables (e.g., time and cost) to understand the behavior of the model and evaluate the extent to which it provides an accurate account of the behavior of the observed system (13). In health care, simulation has achieved some success as a problem-solving tool (3). Moreover, as well as being able to incorporate the aforementioned evaluation measures, it will be posited that simulation modeling offers a systematic approach for addressing key evaluation methodology issues that have been usefully summarized by the seminal Lewin Group report (27). These issues have been identified as technological maturity, focus of evaluation, perspective of evaluation, comparator, randomization, and time horizon. Table 1 defines each of these issues in turn, along with an example of how they are addressed in current telemedicine evaluation studies and how simulation can offer a potential solution to these challenging issues.

From Table 1, it can be seen that current telemedicine evaluations largely fail to address the broader organizational, clinical, and social processes that new technology impacts upon. Some evidence that exists suggests that this is a critical issue and that the focus of the evaluation may be too narrow. For example, Lehoux et al. (17) found that the use of telemedicine did not fit into clinicians' communication routines of consultation and referral. We suggest that a more fruitful direction for the evaluation of telemedicine is to focus on the patient pathway. The patient pathway includes all

the clinical routines (or processes) into which telemedicine is placed, so that it can be assessed on how it sustains or supports variation in clinical practice.

SIMULATING THE PATIENT PATHWAY

Patient pathways are tools that assist in providing general guidelines of care for dealing with individuals and groups of patients suffering from a wide variety of diseases. However, the majority of studies focused on *traditional* patient pathways (23). The introduction of telemedicine, however, offers a new pathway to care, although the impacts of it are even less well understood. To this end, simulation is put forward as a method of modeling pathways that capture the timeline of care from the start to the journey's end.

Discrete-Event Simulation Technique

Discrete-event simulation (DES) offers many features to cope with understanding the complex nature of health care systems, of which the patient pathway is a clear example. There are three critical steps to the technique that are advantageous for representing pathways, which can be described as follows: (i) *Understanding the system or process to be modeled*—this is in terms of its main entities (e.g., patients), events (e.g., clinic visits), and decisions (e.g., referral of patient for consultation) and must be achieved for the subsequent model building to have a good representative basis; (ii) *Changing the parameters of the model (e.g., time and cost)*—this step can suggest (based on mathematical distributions) the optimum capacity of the system in the present and for the future given different scenarios; and (iii) *Understanding the inter-relationships between different entities, events, and decisions in the system*—this step can identify the interdependencies of variables and the effect of changing one has upon another.

The simulation's significant feature is its capability of performing "what if. . . " type analyses through the manipulation of variables to understand the inter-relationships within the model and, hence, the real system. This iterative nature to the modeling process brings about the identification of the optimum system setup. Although simulation is not intended to replace current designs of evaluation studies, acceptance of any new approach to studying health care problems needs to be justified on the professed benefits of the proposed solution option.

Benefits of Simulating the Patient Pathway

Whereas simulation has the potential to overcome many of the problematic issues in telemedicine evaluation (as shown in Table 1), the true value of the approach rarely has been realized, given the narrow focus to which it has been applied previously, typically hospital scheduling problems (11). This quantitative view of simulation modeling—as a way of calculating outcomes—has often failed to produce results that can be readily implemented in real-life applications. Moreover, the telemedicine literature, in particular, reveals a paucity of studies that have undertaken any simulation, except for perhaps two notable examples (6;18). The impetus, therefore, clearly exists for a debate on the *conceptual* issues of research in telemedicine, given the problems with current evaluation techniques (4). Robinson (24) has called for a debate on simulation study as a mode of practice in various domains. We contend that this debate is necessary within health care and propose that a starting point for this discussion is on evaluating telemedicine from a simulation of the patient pathway.

Patient pathways do not physically exist; therefore, methods of computerizing pathways have demonstrated some degree of success (7). The understanding that is gained through simulation is of a greater value than the pure numerical values produced. We propose, therefore, that simulation be viewed as a tool not to calculate outcomes but to *appreciate* them. This difference is subtle yet powerful. In this manner, the use of simulation will crucially serve to *elicit* the intangibles, such as insight into the way the system actually operates, understanding the variables that can affect the system, and informing decisions concerning the system and their possible consequences.

The benefits of simulating patient pathways are increased when qualitative investigations (e.g., interviews, observations, and so on) are directed at critical points along the pathway so as to supplement the models and understand more holistically the relationship between the interpersonal (e.g., patient satisfaction) and technical aspects of telemedicine (9). For example, to return to the three key measures discussed earlier, in diagnostic accuracy, a control patient group can be simulated to compare the outcomes of consultations with a clinical trial group. This approach has been shown previously to provide an *educational* benefit for informing clinical decision making (14). Furthermore, cost-effectiveness measures can also be extended to produce cost per quality measures of outcome in terms of the quality adjusted life years for specific health care interventions (10). This can have an important *personal* benefit, particularly for the patient in terms of establishing the relationship between their illness and the likelihood of health care saving their life. Moreover, incorporating patient satisfaction measures is possible by converting patient responses into an appropriate numerical scale and applying these figures to the model. This strategy can have a *behavioral* benefit in being able to determine fluctuations in patient satisfaction and pinpointing problem areas.

Telemedicine Patient Pathway: An Illustration

To illustrate the potential of simulating patient pathways, leg ulcer sufferers were selected as case examples, given the access to patients who have followed a traditional

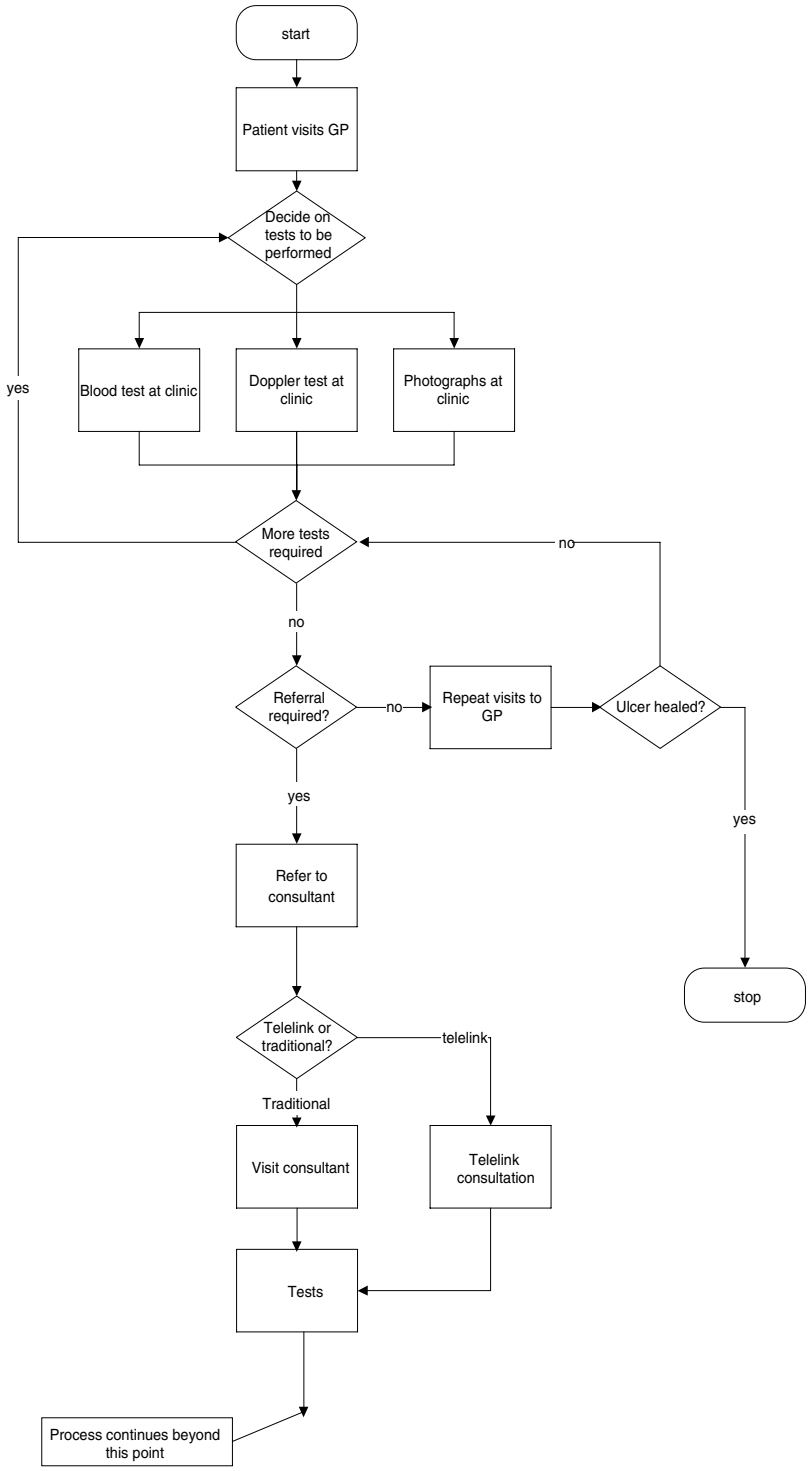

Figure 1. Leg ulcer patient pathway.

and telemedicine patient pathway. Figure 1 is a graphic representation of part of a leg ulcer patient pathway. Information to structure the pathway and its critical variables is collected from patient records and interviews with doctors and nurses. Figure 1 serves to illustrate all the health care events along this section of the pathway, for instance a tele-link consultation and the relationships between them. Figure 2 illustrates how identical patients can be treated through two systems, both traditional and telemedicine (the timescale for which is provided for illustrative purposes only).

Variables at strategic decision points along the pathway control the flow of patients. These variables alter based

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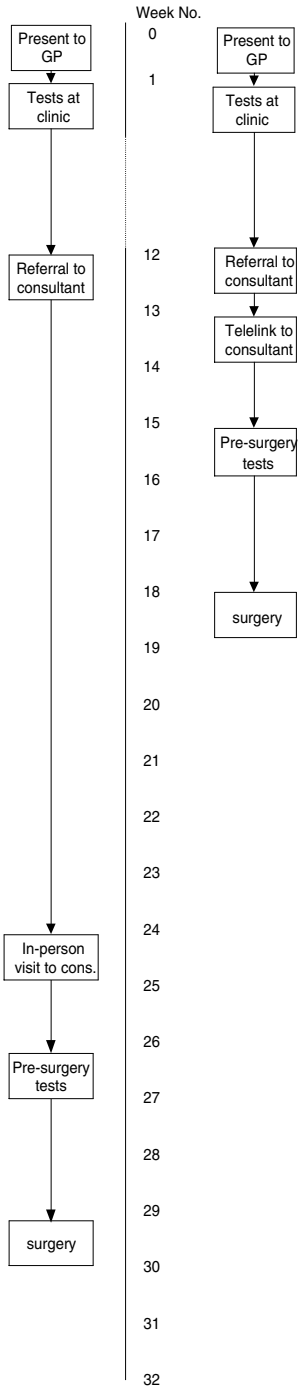

PRESENT TO GP

1. **Patient volume** – the number of patients arriving at the surgery are established in order to determine the capacity that the system currently deals with and how this affects the system.

2. **Patient attributes** – age, severity of condition, and general health were key issues used in clinical decision-making. These were all rated on a scale of 1-3 (with 1 being the youngest/least severe and 3 being the oldest/most severe).

TESTS AT CLINIC (and PRE-SURGERY TESTS)

1. **Costs of tests** – this variable is dependent on *patient attributes* (i.e., the more severe cases will need more tests). It is also dependent on *time* as if the period in between testing at the clinic and pre-surgery is short then only one set of tests will be needed, otherwise they may have to be repeated.

2. **Costs of dressings** – this variable is dependent on *time*, as dressings have to be changed twice a week, during the course of treatment.

3. **Time** – every event has a time delay, which may vary depending on *patient attributes*, whether telemedicine is involved, or the number of tests conducted.

Figure 2. Comparison of a traditional and telemedicine leg ulcer patient pathway.

on data parameters (patient volume), patient attributes (age, severity of condition, and general health), and time, which were deemed important for the treatment of leg ulcers from interviews with clinical staff. These variables can be further manipulated to determine different levels of effect when changing sections of the process (i.e., introducing telemedicine).

DISCUSSION AND CONCLUSIONS

This study has discussed simulation modeling—solely as a mode of practice—for the evaluation of telemedicine in the context of the patient pathway, as illustrated by Figures 1 and 2. Future work will need to computerize the pathway into a dynamic running simulation model by comparing the

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predicted flow of patients with the actual flow along the traditional and telemedicine pathway. This approach will allow the capture of the long-term and organizational impacts of telemedicine implementation. An integral part of the discussion on the potential use of simulation has been the focus on the patient pathway. This focus has provided a compelling example of the importance of evaluating telemedicine in the context of the health care processes into which it is placed. A spotlight on pathways vivifies the collective benefits of simulation that have been put forward by highlighting how telemedicine can be evaluated in relation to the entities, events, and decisions involved in the delivery of care that it impacts upon. On the surface, telemedicine might appear to offer a fast-track system for patients, which can reduce the costs of dressing for leg ulcer patients, for example (as shown in Figure 2). However, Phipps (22) provides a caveat to this in stating that it is important that we understand how optimizing one section of a process (e.g., introducing a telelink) can affect another section further along in the system and potentially induce a bottleneck (e.g., at the surgery stage) given that this section of the process will not have changed. It is suggested that a new challenge for telemedicine evaluation studies is to compile a more comprehensive view of the technology, in looking across multiple aspects of healthcare processes to provide a much-needed commentary on the outcomes of health care and its delivery. To this end, patient pathway simulation has been introduced as a potential evaluation tool for telemedicine to continually monitor clinical practice, the effects of telemedicine, and changing health outcomes.

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