Clinical Outcome, Economic impact of Teledentistry

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Abstract: As expected, technologic innovations in the field of dentistry have been extensive in recent years. Most important advances have been made in the use of computers, telecommunication technology, digital diagnostic imaging services, devices and software for analysis and follow-up. Nowadays, it is hard to imagine a dentistry clinic without computerized patient registry, electronic invoicing, digital radiography, intraoral cameras and digital cameras.

What was considered relatively distant future some twenty years ago, today is the reality in dental clinics. Using most advanced information technology, the science of dentistry crosses much longer distances than it was ever able in the preceding twenty centuries. i.e. the beginning of the new era. New information technology not only improve the quality of management of dental patients, but also makes possible their partial or complete at distances of thousands of kilometres away from health care centres or qualified dentists. However, the primary purpose of these intelligent systems is adequate diagnosis, since the natural disease course has changed.

These systems would not mean a lot without telecommunication assisting the process and sending information almost instantly to interested parties within an institution and all over the world. Networking, sharing digital dentistry information, distant consultations, workup and analysis is dealt with by a segment of the science of teledentistry concerned with dentistry: teledentistry. “Teledentistry” is a synergistic combination of telecommunications technology, Internet and dental practice. It is a relatively new and exciting field that has endless potential.

Keywords: Teledentistry, Telemedicine, Telehealth, videoconference, outcomes, dental hygiene, access to care.

Introduction

In this era of modern medicine, dentistry has been constantly changing with the advent of information and technology. “Teledentistry” is a rising area of dentistry that applies telecommunication and information technologies to facilitate and improve oral health care. It fuses electronic health records, telecommunication technologies, digital imaging and the Internet to support long-distance oral health care, oral health-related education, dental public health and health administration¹⁻⁵.

Teledentistry has many branches like Telestomatology, Teleradiology, Telepathology, Tele oral surgery and Teleorthodontics. The use of teledentistry is growing, but its efficacy for achieving comparable or improved clinical outcomes has not been established in many dental specialties. Most teledentistry programs to date have focused upon distance management and administration of remote facilities, learning and continuing education, consultation and referral services rather than supervision of auxiliaries or direct patient care.⁶⁻¹¹

This paper provides a review of the scientific literature in order to evaluate the efficacy, effectiveness and costs of teledentistry used for direct patient services, specifically clinical outcomes, health care utilization and costs related to teledentistry. These outcomes were selected to reflect a common objective of teledentistry programs - to provide access to quality services while minimizing costs.

Methodology

For the present study, teledentistry is defined as the use of communication and information technologies to provide clinical services from a
distance. The following electronic databases: MEDLINE, PUBMED, EMBASE, COCHRANE, CINAHL, PROQUEST were searched to identify relevant articles.

**Selection Criteria**

**The inclusion criteria were:**
- Publication from the earliest available date to October 2016;
- Language: English
- Some of the abstracts and full-text documents were searched by traditional Web searchers such as Google.com, and documents that seemed to be relevant but did not have a digital version were hand searched.
- The search strategies included subject headings and subheadings (if available) combined with keyword searching. The search concepts included teledentistry, telemedicine, telehealth, remote consultation, cost effectiveness, outcome, dentistry and dental services.
- Only documents for which full text could be obtained were reviewed.
- Studies designed as an interventional study (experimental and observations based on judgments from teledentistry images),
- Used quantitative or qualitative approaches,
- Presented findings related to outcomes or costs.

**Exclusion criteria**
- Studies which included only telephone interventions (unless telephone intervention was one group of the study, with a video component in the other, or unless other technologies were paired with the use of the telephone).
- The technology was smart home monitoring devices,
- Examined telehome care of patients with chronic disease who received only nursing interventions with no dental care objective, reported only the development phase of the technology (i.e., feasibility of the technology in a lab setting),
- Studies were also excluded if they provided insufficient information to allow adequate interpretation of the study design, measures or results, or if they were only found in abstract form, in abstracts or posters from conference proceedings.

The articles were reviewed to include details pertaining to the study quality, such as study design, number of subjects and study population, as well as the description of the program and technology used. The following types of reported outcomes of interest were recorded:

- **Clinical:** Outcomes related to service delivery, such as attendance and adherence to programs and recommendations, as well as health care provider and staff satisfaction with the program
- **Health care utilization:** Events that occur outside the program’s scope and that the program may aim to reduce or increase, such as hospitalizations and admissions
- **Costs:** From the perspectives of patients, providers or organizations, all costs (savings and/or expenses) associated with the use of teledentistry.

**Results**

15 studies were retained after the initial screening of 54 titles, abstracts and the full-text retrieval of pertinent articles. Exclusion criteria did not limit the type of experimental or observational design. **Clinical** Articles of clinical outcomes focused on validity, accuracy and reliability of teledentistry in screening for dental caries, identification of oral mucosal lesions, trauma, orthodontic consults and referrals, periodontics and pathology. **Dental Caries**

Five studies comparing clinical and teledentistry screenings for dental caries examined the following: feasibility validity, reliability prevalence and inter-examiner agreement. Clinical screening methods varied among the studies from use of a mirror only to use of a mouth mirror, light and explorer by a calibrated pediatric dentist. Not only did methods for clinical examination differ, but also the number of intraoral images captured for teledentistry screenings ranged from no specific number reported to 6 images. Cameras used to capture images and number of teeth captured in an image also varied among the 5 studies. Type of personnel differed among the studies. In one study, 6 telehealth assistants captured images of children in 6 Head Start centers for transmission to a dental examiner who would screen for DFS to determine prevalence of dental caries. In another, a registered dental hygienist and registered dental assistant performed both clinical and teledentistry screenings. In another study examining the validity of teledentistry screening, the clinical screening was performed by an experienced dentist using light, mirror and explorer to establish a gold stan-
dard against which the teledentistry screening by 4 dentists was measured.  

No statistical difference was found between teledentistry and clinical screening for dental caries. Sensitivity ranged from 98 to 100% . The use of teledentistry screening and clinical screenings for dental caries in young children was shown to be both cost-effective and valid. The Kappa statistic for reliability between clinical and teledentistry screenings for early childhood caries ranged from 0.58 to 0.61. Identification of primary teeth in need of restoration resulted in Kappa 0.93. There was no significant difference between the use of clinical and teledentistry screenings in assessing prevalence of early childhood caries. The mean of DFS with clinical examination was 1.40 (SD=4.07) and with teledentistry was 1.56 (SD=4.15).

Orthodontics

Teledentistry examination to identify the need for orthodontic referral was found to be as effective as referral from clinical examinations. Orthodontic referral rates for teledentistry and clinical examinations were compared. Acceptance by orthodontists of children screened using teledentistry or clinical methods was also reported. Sensitivity for referrals using teledentistry was 80% and specificity 73%. Use of teledentistry for referrals resulted in a positive predictive value of 0.92. The negative predictive value was 0.50, which occurred due to half of the children (n=22) that would have been accepted by an orthodontist if a clinical examination had been performed. The Kappa score of 0.46 reflects moderate agreement of orthodontist acceptance of teledentistry referrals. The teledentistry group was less likely to refer an individual who did not need orthodontic care than those who made referrals based on clinical examinations.

Teledentistry has been used in offsite clinics to assess orthodontic need and to provide instruction for students providing interceptive orthodontics. When compared to a second group of students at a site with face-to-face faculty supervision, the assessment of need and development of interceptive appliances was found to be as effective as the site where faculty were present.

Periodontics:

It was by the US Army when teledentistry was first tested at Fort Gordon, Georgia in July 1994. In this study in conjunction with an Intraoral camera a dental image management system was used to capture color images of a patient’s mouth. Using a 9600 band modem these images were then transmitted from the dental clinic over to Fort Gordon, Georgia, a distance of 120 miles. Fifteen periodontal patients were referred to Fort Gordon for surgery. One week after their surgery, each patient reported to Fort McPherson for suture removal and intra-oral imaging. At the time of suture removal, color still images were obtained of the surgical sites and these images were transmitted to Fort Gordon for examination by the Periodontist who performed the surgery. The results of this study showed that 14 of the 15 patients saved the return trip to Fort Gordon. The patients uniformly felt that they had received better care than they normally received and were especially pleased at the elimination of the long trip to Fort Gordon. The dentists were also comfortable in their ability to make proper decisions and diagnoses using the equipment.

Endodontics

The accuracy and reliability of teledentistry for identifying canals within extracted molars resulted in moderate agreement among 20 examiners. A total of 88% of canals in the 50 permanent molars were identified correctly from photographs. Dentists with >10 years of experience were more accurate in detecting canals than those with less experience. Accuracy of detection was also greater in mandibular molars than maxillary molars.

Health Care Utilization

A total of 3 studies reported health care utilization outcomes. The commonly reported outcomes include the effect on referral rates, inappropriate referral rates, failed appointments, prevalence of caries and general dental practitioner visits. Inappropriate orthodontic referrals were lower in the teledentistry group (8.2%) compared to the control group (26.2%). Previous inappropriate orthodontic referral rates were up to 45% resulting in poor use of professionals’ and patients’ time.

In a comparative-effectiveness study, the care utilization in preschool urban children enrolled for teledentistry examinations was as effective and accurate as traditional clinical exams for dental caries screening. No significant difference was found between groups.

Costs

Different approaches have been used for assessing the economic impact of telehealth projects with diverse levels of acceptability. Jester and Hicks and Dixon identify three methods to calculate the cost-effectiveness between two health interventions: cost minimization analysis (CMA), cost-benefit analysis (CBA), and cost-effectiveness analysis (CEA). Reardon also identifies the return of investment, and the functional economic analysis to be used in telemedicine projects.

CMA assumes that both alternatives (TeleHealth Care and standard care) have the same effectiveness in terms of health outcomes, but that they are different in terms of costs. In CMA,
changes in costs are considered but health outcomes are kept unchanged. This assumes that, for instance, THC and standard care have the same reduction in hospitalization days, but that their cost differs, so decision-makers have to consider only the differences in costs to decide which alternative is less expensive.

CBA acknowledges that very few projects are equally effective but different in costs. Thus, changes in costs and health outcomes are considered simultaneously by giving a monetary or numeric value to the changes in health outcomes. Although this method takes into account changes in both variables, the idea of giving numeric values to outcomes such as patient satisfaction or quality of life is not always acceptable for decision-makers in the healthcare field.

CEA appears as a solution to this issue since it measures the benefits in nonmonetary terms. In CEA, each outcome is defined according to its specific unit so the final ratios will show a relation between economic and health outcomes. Therefore, the final decision will depend on the ratio that the decision-maker considers the best. CEA compares the cost and health outcomes of an intervention to assess whether it is worth doing from the economic perspective. This arises from the concept of opportunity cost, that is, the value of resources given up in a decision. This definition accepts the fact that there is always a trade-off in a decision between two alternatives. Hence, whatever may be the final choice would always represent a “sacrifice.” In economic terms, a sacrifice is understood as something valued that is given up. In THC projects, given resources are usually monetary and received benefits are in terms of health outcomes. As such, the idea is to select the option that represents the smallest sacrifice.

Two studies presented some type of cost analysis of the teledentistry intervention.\textsuperscript{11,15} One examined costs from the patient’s perspective using a questionnaire to obtain information concerning distance, travel time and cost to visit a specialist’s hospital. Cost of time from work and overnight accommodations were also assessed. Travel time resulted in an average of 12 hours lost productivity for those from Orkney and 2.5 hours for patients from Kingussie.\textsuperscript{11} Ignatius et al’s 2005 report studied cost of teledentistry technologies for 26 dental specialist trainees in 8 cities in Finland.\textsuperscript{13} Costs were calculated for travel, purchase and equipment operation. The use of teledentistry was estimated to save each student at least 43,600 Euros.

Discussion

The use of teledentistry for screening of oral diseases to determine prevalence and treatment needs, and provide access to specialists for consultations, is promising. Oral diseases impact health and quality of life for many. Expanding the roles of dental hygienists and removing practice restrictions would increase the number of oral care providers who could perform screenings, care and referrals using teledentistry.

This review of teledentistry showed that although there is heterogeneity between studies in terms of study designs, clienteles, settings and outcomes measured, a trend exists supporting the efficacy and effectiveness of teledentistry. Many quality studies, including studies with control groups, reported similar or better clinical outcomes when compared to conventional interventions. Use of teledentistry resulted in slightly higher DFS scores than those found in clinical examinations of the same children \textsuperscript{10,17,20,22,27} When screening groups of young children, referral for care based on a false positive is not as detrimental as non-referral based on a false negative.

One study reported the incorporation of a 1 credit hour, 15 week teledentistry course in a dental hygiene program.\textsuperscript{16} Students’ knowledge, attitudes and confidence were evaluated prior to and following the course. Confidence, knowledge and attitudes were significantly different on 9 of the 10 item questionnaire following the course. Including a teledentistry course within the curriculum provides oral care professionals the skills needed to improve access to care.

Overall, satisfaction ratings regarding the use of teledentistry were very high from both patients and therapists, regardless of the patient population, setting or study design. However, certain measurement issues limit the usefulness of the reported data. For example, the tools used to measure satisfaction are for the most part poorly described and not standardized. The underlying satisfaction concept is often vague, making the interpretation of satisfaction findings unclear. Findings are generally limited to satisfaction with the technology, the service received/given, but there are no details of the service delivery or their experience in the program.

The findings in this review are similar to the conclusions arrived at by Mair\textsuperscript{33} as well as Williams et al\textsuperscript{34} in their systematic reviews of studies reporting patient satisfaction with telemedicine. Continuing to measure user satisfaction in the current manner will simply confirm previous findings of acceptability of the
technology, but will not increase the understanding of the underlying processes of teledentistry use. A better understanding of satisfaction remains an important area for future research in teledentistry.

Reduced costs or better resource utilization is often cited as one of the main goals of teledentistry. In conducting cost analyses, it is crucial to identify from which perspective the analysis is being conducted - in other words, who is defraying the costs or achieving the savings, be it the patient, caregiver, clinician, health care organization, health care system, reimbursement agency, society and so on. None of the studies presented here calculated costs using the same elements.

Further studies must be done to demonstrate the efficacy of teledentistry for diagnostic and management decisions. Large-scale RCTs must be done to identify the health outcomes whose benefit appears most promising. If the goal is to show comparability to usual care, then studies must provide adequate statistical power to show that the lack of a difference truly exists. Small studies with inadequate power are not good evidence. The fact that teledentistry is an emerging technology is not a reason for failing to perform appropriate evaluation studies. Rather, new methodologies such as "tracker trials" should be used to assess it systematically. Tracker trials are designed to assess new and/or rapidly changing interventions and compare efficacy not only of the general intervention but also specific instances of it, such as a newly-developed approach that has become available after the general trial started.

Conclusion

From the data available, teledentistry seems to be a promising path for access to care in rural and urban settings. Teledentistry has benefited people’s life to a great extent by local dentist by contacting specialist proving a potential source of health care. Although there is heterogeneity between studies in terms of study designs, settings and outcomes measured, there is a consistent trend supporting the efficacy and effectiveness of teledentistry. Further research in the area of teledentistry, with methodologically stronger studies examining clinical outcomes, health care utilization and costs in greater depth are critical for evidence base.

References :


