

## The Implementation of Teledentistry for Pediatric Patients

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**Abstract**—The present study tested a prototype teledentistry system in which regional Community Health Centers are linked to the Melbourne Dental School or the Royal Children's Hospital in Melbourne (RCH). Three general dental practitioners (GDP) working in community dental clinics in the Australian state of Victoria were trained to manipulate an intraoral camera and to use existing ICT infrastructure to communicate with a dental specialist at RCH and transmit video images for remote assessment. Participants were recruited from the RCH's patient database for cleft lip and palate (CL&P) and orthodontics, living in the selected rural locations. Patients/parents of patients participating in the study completed a questionnaire to assess their experiences with the program. Forty-two assessments/consultations were conducted; 26 CL&P patients, and 16 in orthodontics. For most patients, the outcome of the consultation was the avoidance of trips to the centrally located RCH for initial assessment and/or follow-ups. This field trial provided initial evidence on how teledentistry might improve access to specialist care; identified broader community benefits for both the family and the services providers. From the RCH perspective, the potential reduction of inappropriate referrals with the concomitant reduction of waiting lists for specialist consultation, were important advantages of teledentistry.

**Keywords**—oral health; teledentistry; intraoral camera; cleft lip and palate.

### I. INTRODUCTION

In the last few decades, the implementation of teledentistry has been widely witnessed by various institutions and organizations concentrated mainly in the United States and Europe, but such trials also occur in many other parts of the world. A recent review of the teledentistry literature concluded that most reports referred to pilot projects, and the remainder concentrated on experimental

stages and short-term outcomes, and were descriptive in nature. Despite these limitations, these trials prove that this technology can be successfully implemented in different health settings [1]. The positive outcomes and positive health professional-patient experiences described are very encouraging and clearly indicate that teledentistry works by delivering practical solutions [1] [2].

Teledentistry is particularly well suited for children. Using teledentistry, children's teeth were screened for early childhood caries, during which it was reported that all children liked seeing their teeth on the computer screen [3]. Dental imaging was seen as a game by them, rather than as a dental examination. Moreover, as no instruments are used and the camera head does not need to be inserted far into the child's mouth to obtain dental images, there was less risk of uncooperative behavior by the very young child or toddler than that posed by a conventional dental examination. Child comfort is also increased when the teledentistry examination is conducted in a familiar environment, as opposed to a clinical environment. This resulted in children being more enthusiastic and co-operative during the imaging and recording procedures [3]. In addition, parents and children do not have to take time off work or school for travel, and a child can be tracked easily to determine whether treatment has been rendered, or if an emergency evaluation is needed.

In the state of Victoria, Australia, general dental services are provided by the State to all school children and those adults from lower socioeconomic groups, with strict eligibility criteria and waiting times of up to 18 months [4]. Thus, to see a dentist specializing in pediatric dentistry, access in remote areas is limited, and often there is a long waiting list for both consultation and treatment, especially for specialist care.

Teledentistry has advantages as a method of providing oral specialist services [5]. For example, there are clear advantages if patients could be examined by a dentist/dental therapist with links to a centralized pediatric dentistry specialist, who could provide support with diagnosis and treatment planning and prioritization via tele-consultation and the use of intraoral cameras. Rural community clinics and isolated dental practices are likely to benefit most from this approach. More patients could receive assessment and treatment, since patient care would be effectively triaged at the community level for future care in a specialist centre. For patients, it would reduce the cost of treatment and the need to travel to Melbourne to be seen by the specialist, because their problems were previously identified and planned via teledentistry.

From a public health perspective (i.e., Royal Children's Hospital), if this system is implemented, this screening would save considerable time and decrease waiting lists [6]. Specialists might conduct the teleconsultations from a computer in a dedicated room, this would mean that the time in the clinic could be used entirely to treat patients [7]. The result would be a more productive use of clinical time and resources.

The present project builds on a University of Melbourne Institute for a Broadband Enhanced Society (IBES), Project Seed Grant, which tested the technology under laboratory conditions (proof of concept) and developed the instructional material for non-oral health professional operators [8]. The validity of the teledentistry approach was also investigated and there was no loss in quality compared to face-to-face examinations [8]. Thus, results demonstrate that the proposed teledentistry approach for oral health screening using an intraoral camera is feasible and reliable as an alternative to traditional oral health consultation.

This paper is organized in six sections. The first Section provides the foundation for the need for teledentistry in this population. The second Section is concerned with the aims and objectives of the paper. Sections 3 describes the methodology used in this field trial of teledentistry. Section 4 describes the results of the trial, including interviews with personnel and responses from parents of the children involved in the program. Sections 5 and 6 discuss the results of the trial and conclude on its findings, respectively. Further steps are also discussed in last section.

## II. AIMS AND OBJECTIVES

The specific objectives of this study were to: assess the feasibility of using teledentistry for pediatric teleconsultation in children and adolescents living in rural and remote areas of the Australian state of Victoria; and to assess the participants' (patients and dental practitioners) views about the structure, content and delivery of the program.

The working hypothesis of this study is that an initial assessment by a consultant, using teledentistry, would decrease the number of long-distance trips needed by patients located in remote areas to visit the RCH to see a specialist (i.e., orthodontist, pediatric dentist), thereby avoiding disruption and reducing costs. In addition, the use

of teleconsultation as a method of screening patients would help to categorise treatment priority avoiding the need for unnecessary referrals and for the patient to travel to an often distant centre for additional assessment.

Additionally, as there is some tension between the increased need for oral health care and a financial climate which limits the oral health budget, the study included an evaluation of whether this innovative oral health care program could be implemented under current financial arrangements.

The plan was to conduct remote assessments/consultations in three specific specialist service areas:

- 1) Cleft lip and palate (CL&P). Support for the timely management of CL&P conditions, which have involvement of pediatric dentistry as part of the multidisciplinary team.
- 2) Dental trauma. Support for the management of oro-facial trauma in rural or remote Community Health Centers, and isolated practices. Patients who present with a trauma can be imaged by trained personnel, a pediatric dental consultant views the case from a remote place and a rapid response is obtained [9].
- 3) Orthodontics. Malocclusions remain untreated due to lack of (or restricted access to services) (barriers include financial, geographic, access to specialist).

It was considered that this assessment would provide initial understanding of the implementation challenges and associated issues to aid decision making in expanding those services to other underserved populations and locations.

## III. METHODS

Three community dental health clinics in rural areas of Victoria were recruited to participate in this project. These clinics were located in Rosebud, Shepparton and Geelong, and worked in partnership with the University of Melbourne's Melbourne Dental School and the Royal Children's Hospital of Melbourne, which acted as the central site.

Training was provided for the staff involved in the project and an instruction was manual prepared to assist with use of the intraoral camera. Three general dental practitioners (GDPs) working in community health centers at each of the three remote locations manipulated an intraoral camera. They used existing ICT infrastructure to communicate with the dental specialist at the Royal Children's Hospital of Melbourne (RCH) and uploaded and distributed the images to the pediatric dentist at the RCH for remote assessment.

For the purposes of this trial, assessment of fifty patients was considered to be adequate to meet the specific objectives of this study. The study included children that would generate payment for general consultation and for specialist consultation. Thus, participants were recruited from the RCH's cleft lip and palate (CL&P) and orthodontics patient database who also lived in the selected locations.

Patients were introduced to the study by the local GDP. When the patients, or their primary carers, expressed interest

in participating, each received a Plain Language Statement describing the study and a Consent Form. Once informed consent was obtained, patients underwent an oral health assessment. Patients/parents of patients participating in the study completed a questionnaire to assess their experiences with the various aspects of the program. This included satisfaction, acceptance and practical issues of the teledentistry approach and participants were also invited to discuss any concerns associated with the project.

In the present study, a teledentistry installation was organized using a SOPROLIFE® [10] intra-oral camera (Acteon, France) to capture video and transmit both audio and videos in a high definition software platform (i.e., GoToMeeting®) over the Internet. Additionally, each GDP was sent a web camera (Logitech) to connect to his/her computer. Mpeg4 audio was also transmitted at 128kbit/s along with the images via the use of Clear One Chat 50 model microphone/speaker units also connected via USB cables. This allowed excellent quality audio communications between the patient and clinician nodes. The RCH has an excellent review system available for teleconsultation as a two-way interactive consultation [11], however, it had been rarely used for dentistry prior to the present study.

Rather than arranging video conferencing in an ad-hoc basis, it was thought to be more effective if the consultant would be available during a set time each week. Teleconsultations were organized once a week on Fridays afternoon.

The trained GDP obtained the reason for the consultation, manipulated the intraoral camera and recorded findings for each participant. The remote pediatric dentistry/orthodontic consultant, in collaboration with the local GDP, recorded findings for each participant. An off-site pediatric dentistry consultant and orthodontist located at the RCH, performed the 'virtual dental assessments' and was available to discuss the case with the GDP in real-time teleconferences. Treatments needs were determined by the specialist and the specialist also evaluated whether a referral to the RCH was required.

The remote examiner assessed the patient's needs and provided advice and follow-up to the GDP on how to manage the condition either locally or by referral for specialist care (e.g., orthodontics, pediatric dentistry) as required. They could also organize a specialist consultant at the RCH or Royal Dental Hospital of Melbourne. Additionally, the remote examiner provided advice to the health staff at the local Community Health Centre, or to the parents of the child.

Data collection extended between August and December 2013. At the end of the cycle GDPs who collected the information were sent a summary evaluation form in which they reflected on their acceptance of the practice, and their experience as a whole. The utility of the instructional training kit and any other issues associated with the project were also assessed. The evaluation form consisted of statements that participants rated on a five 5-points likert scale, depicting their level of agreement with the statement (1 'Strongly agree'; 3 'Neutral'; 5 'Strongly disagree'). The summary evaluation also contained four open-questions, so

participants could include their thoughts about their experience and critiques.

Because of the small sample size, the analysis will only include basic descriptive information on the distribution of selected socio-demographic and outcome variables, and parents' views about the format, content and delivery of the teledentistry program. In some cases, categorical and ordinal data were analyzed utilizing Chi square analysis ( $\chi^2$ ) to compare results between different oral conditions and distribution of socio-demographic and outcome variables. To complement this quantitative description and to obtain a better understanding of the usefulness of this approach, from the perspectives of the users (i.e., parents), a qualitative process evaluation was organized to offer new insights.

Ethical approval to conduct this study was sought and obtained from the University of Melbourne.

#### IV. RESULTS

Three general dental practitioners were recruited for this project. Recruitment of patients took longer than expected as many did not want to participate. The most common answer was that they would come to Melbourne anyway. At the end of data collection, the three GDPs conducted assessments/consultations in two specific specialist service areas; 26 CL&P patients, and 16 in orthodontics. Additionally, one patient presented with Cohen's syndrome. Trauma could not be assessed because no case with orofacial trauma presented during the period of data collection. The analysis that follows does not include the patient with Cohen's syndrome.

Seventeen examinations were conducted in Shepparton, thirteen in Geelong and another twelve in Rosebud. Mean age was 8.6 (4.2) years (See Table I) with significant difference in mean age by oral condition ( $p < 0.01$ ) and by location ( $p < 0.05$ ). CL&P were younger than orthodontics patients (7.2 vs. 10.9 years, respectively). By location, participants from Geelong were younger than those from the other two locations (6.1 vs. 9.3 and 10.3 years). Ages ranged from 1 year and 11 months to 18 years of age. The largest group of participants (41.9%) was between 4 and 8 years of age. The majority of participants (60.1%) were males, with no significant differences by location or oral condition.

For most participants, the outcome of the consultation was the avoidance of trips to the centrally located RCH, for initial assessment and/or follow-ups. For 7.3% of the cases, the follow-up consultation would occur in the three months following the teleconsultation. In about half of the teleconsultations (48.8%), the advice from the consultant was the need for a follow-up visit, which would occur within 6 to 12 months. Another 7.3%, were advised to arrange an appointment at the Dental Department of RCH. For 17.1%, the consultant requested additional information (e.g., radiographs), or the type of general dental treatment that would be required (e.g., restorations, extractions, oral hygiene instructions, etc.) and were referred to their local clinic. For the remaining 20% ( $n = 8$ ), the patient was not eligible for treatment at public clinics, and in those cases advice was provided on alternative treatment avenues for

initial evaluation (e.g., the Royal Dental Hospital of Melbourne or local specialists). This proportion would represent inappropriate referrals to the RCH. Inappropriate referrals represented 44% of the orthodontics consultations.

TABLE I. PARTICIPANTS CHARACTERISTICS AND OUTCOME OF THE TELECONSULTATION BY ORAL HEALTH CONDITION

	Oral condition		
	Cleft lip and palate	Orthodontics	Total
Age (mean and s.d.)	7.2 (4.3)	10.9 (2.6)	8.6 (4.2)
Sex	n (%)	n (%)	n (%)
Male	18 (69.2)	8 (50.0)	26 (61.9)
Female	8 (30.8)	8 (50.0)	16 (38.1)
Location			
Shepparton	10 (38.5)	7 (43.8)	17 (40.5)
Geelong	13 (50.0)	- (0.0)	13 (31.0)
Rosebud	3 (11.5)	9 (56.2)	12 (28.5)
Outcome	a		
Review next 3 months	3 (12.0)	- (0.0)	3 (7.3)
Review at 6 months	10 (40.0)	- (0.0)	10 (24.4)
Review at 12 months	8 (32.0)	2 (12.5)	10 (24.4)
Referral to CL&P/Ortho/RCH <sup>b</sup>	3 (12.0)	4 (25.0)	7 (17.1)
Referral local clinic	- (0.0)	3 (18.8)	3 (7.3)
Referral other	1 (4.0)	7 (43.7)	8 (19.5)
Total	26	16	42

a. Figures do not add due to missing values

b. Cleft lip and palate and orthodontic clinics at the Royal Children’s Hospital of Melbourne

When parents were asked about their level of satisfaction with remote dental assessment, amongst those parents who answered the question (n=33), the majority was either strongly satisfied (82%) or slightly satisfied (12.0%). Another 5% of parents were neutral about the remote assessment (See Table II). Parents described the service provided in these ways:

*“I believe this is a valuable service for rural communities”* (Rosebud-2).

*“They did give us instructions on hygiene and checked up on our upcoming appointment at the RCH”. ...“This was our first experience and we were very impressed”* (Shepparton-5).

The majority of parents (75.6%) commented that the most valuable element of the remote dental assessment was the avoidance of travel to the city to visit a dental specialist which caused disruption to family routines, and was often difficult and expensive to organize. Parents commented:

*“Not needing to take the day off to drive to Melbourne for five minutes appointment”* (Shepparton-9).

*“... the advantage of not having to travel to Melbourne is great, plus money saving”* (Shepparton-2).

Parents considered the teleassessment as appropriate and would ‘strongly recommend’ or ‘recommend’ the practice to other people (97%). One parent (3%) slightly would not recommend remote examinations to other parents. No reason was given for that opinion.

The majority of parents (90%) found it very easy/easy to understand the instructions received from the remote examiner. One parent indicated: *“Amazing that they can consult this way”* (Rosebud-8). On the other hand, four parents (10%) were neutral about understanding of instructions received from the remote examiner.

TABLE II. PARENTS’ RESPONSES TO TELEDENTAL ASSESSMENT QUESTIONNAIRE (%)

1. How satisfied were you with the remote dental examination? <sup>a</sup>				
Strongly satisfied	Slightly satisfied	Neutral	Slightly dissatisfied	Strongly dissatisfied
82.0	13.0	5.0	-	-
2. If remote examinations were available for patients, would you recommend them to other people?				
Strongly recommend	Slightly recommend	Neutral	Slightly not recommend	Strongly not recommend
86.0	11.0	-	3.0	-
3. Were instructions from the examiner in the remote examination clear and easy to understand?				
Very easy	Slightly easy	Neutral	Slightly difficult	Very difficult
69.0	21.0	10.0	-	-
4. How satisfied were you with the review of your dental needs by the remote dentist?				
Strongly satisfied	Slightly satisfied	Neutral	Slightly dissatisfied	Strongly dissatisfied
74.0	21.0	5.0	-	-
5. How appropriate was the format of the remote dental examinations?				
Very appropriate	Slightly appropriate	Neutral	Slightly inappropriate	Strongly inappropriate
74.0	20.0	3.0	3.0	-

a. N= 39

When parents were asked about how satisfied they were with the review of oral health needs, the majority was either strongly satisfied (74%) or slightly satisfied (21%), two CL&P’s parents (5%) were neutral.

The majority considered the format of the remote dental examination to be either very appropriate (74%) or slightly appropriate (20%). On the other hand, one parent (3%) was neutral about its format and another (3%) considered remote dental examination to be slightly inappropriate. No reason was provided for that view, but they were a child with CL&P’s parents.

No statistically significant differences were present in the parents’ evaluations by oral conditions. The exception was the level of satisfaction with the review, where CL&P parents tended to be more “Strongly satisfied” than orthodontics case’s parents (84% vs. 57%, respectively; p<0.05).

The GDPs recruited were able to operate the camera, conduct intraoral examinations and transmit the information accurately. They provided feedback on the training material presented (i.e., a hard-copy, on-line manual and demonstrations). There was general agreement that the material presented was clear and relevant to the purposes of this project and that the information provided in the manual

and in the training was helpful in providing the necessary step-by-step information to conduct the oral examination, operate the camera, send the information, etc. However, they were neutral regarding the length of the material. GDPs considered that the manual provided less relevant and sometimes unnecessary information to oral health professionals, (e.g., dental anatomy).

On the question about the training received, the GDPs indicated that they may need more practice before starting examinations outside the study. One GDP commented about the need of more practice time to manipulate the intraoral camera, in particular, to get good images of the maxillary arch.

When asked about the relevance of the teledentistry model in their workplace, they indicated that the technology could be expanded to other areas in dentistry, for example dental trauma, dental emergencies, and the provision of treatment to those who cannot travel.

## V. DISCUSSION

The main aim of the present study was to address key priorities (i.e., “*Children and Adolescents*”, “*Improving services to rural communities*” and “*Potential benefits of technological innovations in dentistry*”) established by Australia's National Oral Health Plan 2004-2013 [12]. The study targeted children and adolescents living in regional and remote locations, and proposed the use of teledentistry to provide an additional step in closing the gaps in the provision of sustainable oral health care services to underserved areas of the country (e.g., rural areas). Rural and regional Australia has major access to oral health workforce shortages, in particular oral health specialists (e.g., oral medicine, pediatric dentistry, maxillo-facial surgery).

The major outcome of the present study was the successful trial of an alternative model for pediatric oral health service provision in remote and underserved areas via a teledental diagnosis and teleconsultation model. The trial provided general and specialist oral health care support to local facilities to assist in regular and timely oral health checks using a GDP in the first instance, and subsequent specialist dental services when the required treatment was identified. In so doing, the trial showed that pediatric teledentistry is a viable solution, in terms of time, stress, and money saved for parents and children who were able to avoid travel to the city for consultation. Furthermore, the concept of teleconsultation was well received by parents and patients and by the GDPs. However, this support must be evaluated with caution in view of the sample size.

Teledentistry can be a highly effective method for enhancing early diagnosis and referral for patients who otherwise might not receive timely care. Additionally, today's high resolution and reliable digital and online technology makes it possible to be connected for distant oral health promotion, education, and assessment, transcending social and geographic barriers.

Findings would indicate that this is a valid, efficient and time saving method for clinical screening. This teledentistry study via teleconsultation was successfully in improving accurate diagnosis and appropriate referrals. It was also

extremely valuable in providing feedback to patients, for example, about the need to bring radiographies or about the eligibility of services.

More specifically, in this project, there were reductions in costs to patients. This reduction of costs on the patients/parents side was achieved without increasing costs to the oral health provider. In this telehealth project, both the community health centres and the RCH, charged the services provided within current financial arrangements. Nonetheless, despite these arrangements, GDPs, and to a lesser degree the specialists, put a significant amounts of in-kind time to self-train and setting up the teledentistry installation. However, these must be considered as research driven costs.

While acceptability and cost saving of the study, from the patient perspective, was established, a societal perspective should be the preferred one. From a public health perspective, the evaluation of the success of the proposed model of care and its sustainability will be dependent on the ability to clearly demonstrate service and economic benefits from the services provider's perspective. Supportive business cases, to a large extent, have not been captured by earlier telehealth projects.

The Australian government established funds to provide financial incentives for health teleconsultation with a specialist, consultant physician, etc. to provide teleconsultation to a range of health professionals (i.e., medical practitioners, nurse practitioners, midwives, psychiatrists, and Aboriginal health workers), but that did not include the provision of financial incentives for oral health services or teleconsultations. This incentive ceased on the 30 of June 2014 [13].

Results have been presented in a simple and descriptive fashion and therefore some limitations should be acknowledged when interpreting these findings. Firstly, as with any voluntary study, there is the possibility of a bias in self-reporting of information. Secondly, with respect to sampling, the sample was small in terms of numbers of respondents and not all CL&P or Orthodontics patients registered with the RCH or local community health centers participated in the study. The questionnaire data lacked, in some instances, the necessary depth for a detailed analysis of the overall clinical experience and its context.

Despite these limitations, this field trial provided initial evidence of how teledentistry might improve access to and efficiency of specialist care in various ways; it showed a pathway to improvements in the quality of access and provision of oral health care; it identified potential broader community benefits such as the level of convenience for both the family and the dental specialist; and it provided evidence of the generally excellent levels of acceptance of the virtual examination by patients, parents, and oral health professionals. In the example of teledentistry presented in this paper, oral health screenings were performed by GDPs at distant sites, thus reducing the need for patients and dentists (or dental specialists) to travel to health care facilities, particularly those located in rural areas. Participants were practically unanimous in their satisfaction

with, and appreciation of, the various benefits of the teledentistry services delivered to them.

From the RCH perspective, the potential reduction of inappropriate referrals with the concomitant reduction of waiting lists for specialist consultation, are important advantages of teledentistry, which are clinically important and also have budgetary implications.

Nonetheless, a significant shortcoming of the current oral health system is its failure to take advantage of innovations in health promotion and e-technologies. This failure is also impacted by the paucity of research information informing oral health practices and identifying innovative ways to use e-health and m-health to make preventive and care intervention programs more accessible, particularly for those living in rural Australia. Findings from this study also add valuable information to the discussion about the value and feasibility of this technology, particularly where unmet needs for dental services among children and young people are high and accessibility is low. It is suggested that teledentistry can make a valuable contribution to the delivery of dental care in both the private and public dental settings.

The project could easily be extended as an integrated part of the general adoption of telemedicine/ telediagnosis. Further research will be required to undertake economic and clinical outcome modeling to determine if the teledentistry approach is cost-effective and leads to a similar or better level of care being provided in comparison to the traditional model of oral health assessment. This will lead to more advanced stages of teledentistry implementation, including larger samples, multi-State community-based trials of longer duration of the technology, which will lead to sustained outcomes.

## VI. CONCLUSIONS

Findings suggest that teledentistry may be an important public health measure to improve access to oral health specialist services for populations where referral to specialists is not possible or feasible. Real-time consultation with oral specialists could provide a new avenue for socially disadvantaged children (Poor, rural, immigrants) to receive these services. At present, these malocclusions remain untreated resulting in oral health inequalities.

An important challenge for future trials would be to ensure that tele-oral health models and programs are maintained in a community for a length of time that is sufficient to achieve the stated goals. These trials would necessarily have a highly collaborative, partnership approach, with a strong academic base in rural health issues

to ensure that the results of the present study can be further developed and implemented.

## ACKNOWLEDGMENT

This project was funded by a grant from Google/Institute for a Broadband-Enabled Society, The University of Melbourne. We would also like to acknowledge the pediatric dental consultants, the general dental practitioners and the parents and patients involved in this study.

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