

## Field Testing of Remote Teledentistry Technology

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**Abstract**—In the Australian state of Victoria, only 11% of nursing home residents have seen a dentist in the past 12 months. This study tested whether the use of intraoral cameras by oral health professionals located at remote facilities improved access to appropriate oral health care services for nursing home residents. The support program and instructional kit for camera operators, including the structure, content and delivery of the program, was developed and evaluated. Residents' views about the structure, content and delivery of the program were also evaluated. The intraoral camera was operated by trained teledentistry assistants with the aim of screening residents for oral diseases and pathological conditions. Treatment plans were then developed by remote oral health professionals based on the information collected. The remote assessments were compared with those done via traditional face-to-face oral examinations. Results indicate that the proposed teledentistry approach for oral health screening is

feasible and reliable as an alternative to traditional oral health examination. Residents expressed high levels of satisfaction with the teledentistry service. This study provides an innovative solution towards closing the gap in the provision of sustainable oral health care services to underserved populations (e.g., nursing homes, rural areas).

*Keywords; oral health, teledentistry, intraoral camera, nursing homes*

### I. INTRODUCTION

Improvements in oral health in Australia over the past 50 years have translated into a greater proportion of elderly individuals retaining more of their natural teeth, increasing the prevalence of caries and periodontal disease. Older people living in residential aged care facilities (RACFs) have been identified as a significant risk group for oral diseases in Australia, and the changing demography and oral

health needs of older Australians will present many challenges for the dental profession over coming decades. In 2005 more than 41,000 Victorians lived in high or low-care residential facilities on a permanent basis; with just over half being dentate and having high dental treatment needs [1,2]. Significant barriers accessing dental services exist. Residents are often physically and cognitively impaired, medically compromised and dependent on others to maintain their oral hygiene.

Face-to-face patient examinations are regarded as the most accurate method for correct oral health diagnosis. However in Victoria only 11% of aged care facility residents have seen a dentist in the past 12 months, as there are few dentists available to provide dental care for residents [3,4]. In fact, only half of Victorian dentists reported providing care to residents of RACFs, and those dentists spent on average only one hour per month providing care in this setting [4].

As the capability of information and communication technology (ICT) has risen, the use of ICT for data collection has increased. Expanded use of ICT provided clinicians with alternatives to the traditional face-to-face oral examinations. This shift in focus has resulted in a vast increase in the number of published articles that include some form of either synchronous or asynchronous, teleconsultation/ telediagnosis [5].

A three-stage study was designed to address priorities established by Australia's National Oral Health Plan 2004-2013 for 'Older People' targeting older people living in RACFs, (an underserved, high-risk population and one with major oral health needs) [6]. This project was conceived in an effort to promote affordable, timely oral health care and to test an oral health care model in which ICT is used with the aim of extending clinical care to residents who are physically separated from the examining oral health professional. This study is also a response to serious dental workforce shortages in caring for this group and provides opportunities to supplement traditional methods of oral diagnosis, care delivery and health promotion.

Potentially, this project could benefit an expanding segment of the population in relative and absolute terms; namely, older people living in RACFs and older people living in rural areas. According to the 2006 Australian Census [7], 55-64 year-olds made up 11.8% and those 65 years and over 13.7% of the total Victorian population.

However, older people are proportionately over-represented in rural and regional Australian communities and these communities are ageing more rapidly than their metropolitan counterparts. Therefore, the present intervention potentially targets a rapidly expanding segment of the population with special oral health needs. Other parts of the world have similar demographic and geographical problems making this study equally relevant to them.

This 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 results demonstrated that the proposed teledentistry approach for oral health screening using an intraoral camera was feasible and reliable as an alternative to traditional oral health examination. Stage 2 of this three-stage study involved the field testing of this teledentistry technology and is the subject of this article.

## II. AIMS AND OBJECTIVES

The long-term goal of the project is to test whether improvements in accessibility and appropriateness of oral health services can be achieved by utilizing advanced ICT techniques to screen for oral disease in older people living in RACFs. This paper outlines the results of the second stage of this project, which aimed to assess, on a small scale, but under real conditions, the safety of the procedures, their feasibility, as well as patients' and health practitioners' experiences with the technology. A comparison was conducted between face-to-face-examinations and remote examinations using an intraoral camera.

Three RACFs within the state of Victoria, Australia, were successfully approached to participate in this stage; two in metropolitan Melbourne and one in rural Victoria. Five non-oral health professional teledental assistants (e.g., registered nurses) in these facilities were trained to manipulate an intraoral camera and use existing and introduced ICT infrastructure to transmit video images for remote examination and diagnosis. An oral health professional at the Melbourne Dental School performed a 'virtual dental examination', recorded findings and developed a treatment plan for a group of selected residents.

This Stage had four main objectives:

- 1) assess the feasibility of using teledentistry to screen for oral diseases and conditions and to develop treatment plans for older people living in RACFs;
- 2) identify barriers to the adoption of a teledental approach. These included: a) general staff workload; b) professional culture and acceptance (e.g., morale, motivation, resistance to change, etc.); and c) availability of appropriate equipment,
- 3) test the utility of an instructional training kit
- 4) assess the residents' views of their experiences during delivery of the program, as well as feedback and information provided during the teledentistry consultation.

## III. METHODS

Although sample size calculations are not strictly necessary for a pilot study [9], a sample size of 50 residents was considered to be adequate to meet the general aims of this study. A 20% attrition rate was expected over the six months duration of the field component of this study - 62 residents were recruited initially.

To participate in this teledentistry study, the resident was required to have the ability to understand and to provide independent informed consent, the ability to communicate with the health professional and to undergo a 15-20 minute oral examination.

A SOPROLIFE® intra-oral camera was used to capture video via a custom video streaming software platform designed for the project [10]. Simulations were conducted in the Institute for Broadband Enabled Society (IBES <http://broadband.unimelb.edu.au/>) test-bed facility. The intra-oral camera was connected via a USB cable to a laptop or mobile tablet used for bed side evaluations, containing the software that compressed and encoded the 25 frame-per-second video into an mpeg4 video stream of at least 3Mbit/sec bandwidth, and preferably a 5Mbit/s stream if network conditions allowed. This bandwidth was found to give the clinician sufficient quality to interpret the images received and removed blurring due to the motion of the camera [8]. The clinician viewed the incoming video via a PC connected to a large monitor. A large screen facilitated simultaneous viewing of both the intra-oral camera video as well as that from a second web-cam, a high definition Logitech model C920 model, capturing the overall interaction between patient and the intra-oral camera operator. This was also streamed as an mpeg4 video of minimum 3Mbit/sec bandwidth. 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 patient and clinician ends. For test sites that could not accommodate a 3Mbits/s stream reliably a Store and Forward version was developed that enabled the mpeg4 file to be stored on a central server for asynchronous download by the dentists. Each examination lasted approximately 15 minutes and each minute of video created a file of approximately 1GB. Thus, the video files were large (i.e., 15 minutes produces a 15 GB file).

Using a teledentistry installation each participant received a 'virtual' oral examination, including dental and oral mucosal assessments conducted with the assistance of a trained registered nurse (RN) at the RACF's facility using an intraoral camera operated in communication with a remotely located oral health professional. Training of the intraoral camera operator involved three hours of direct contact, a sixty-six page training manual including diagrams with content organized in five modules, and up to ten hours of practice examinations.

The oral health professional was able to communicate in real-time with both the resident and the intraoral camera operator (i.e., the RN) via a video link to assist in taking a history, and to direct the RN where necessary in the use of the intraoral camera. To have communication in real time we used Skype® and Vido®. However, there were several problems with Vido due to firewall settings.

The information obtained from this examination was recorded and transmitted to a server for review of the 'virtual dental examination' to be performed remotely at a later time. Information was registered on a conventional Dental Health Services Victoria's chart for the generation of treatment plans by qualified clinicians at the Melbourne Dental School, University of Melbourne.

On completing the virtual oral examination the resident was asked to complete a seven-item teledentistry assessment

questionnaire to assess his/her views on the approach. As further verification of the approach, the interaction, the clarity and facility to understand communication between the oral health professional and the resident was examined for the conventional face-to-face and remote communications.

Ten residents received a second oral examination by a different oral health clinician. This was a traditional real-time examination (the clinician present in front of the patient) with findings recorded on a conventional chart.

RNs who collected the information for this project completed a questionnaire to assess their initial attitude to, and acceptance of the practice, and their overall experience with the teledentistry approach. The utility of the instructional training kit and any other issues associated with the project were also assessed.

Data was collected extended between October 2012 and June 2013.

Descriptive analysis was used to illustrate the participants' views about the format, content and delivery of the teledentistry program. The level of inter-examination reliability for the degree of consistency of the two sets of examinations has been assessed using the kappa statistic.

Ethical approvals to conduct this study were sought and obtained from the University of Melbourne

#### IV. RESULTS

Fifty residents from three RACFs participated in the trial from the 62 initially recruited; with 58% being female. A teledentistry installation enabled five trained intra-oral camera operators (registered nurses) to record, use and transmit video images for the generation of treatment plans by qualified clinicians at the Melbourne Dental School, University of Melbourne. Information from the remote examination was compared with a real-life dental examination. The intra-examiner agreements for dental examination parameters were reported as excellent (Kappa=0.83).

When residents were asked about their level of satisfaction with the examination, the majority of the residents were either very satisfied: (46%) or slightly satisfied (38%) with the format of the remote dental examination. The majority would also recommend (strongly: 46%; or slightly: 46%) a remote dental examination to other people of their age and background. When asked about the reason for not recommending this assessment, the comments were related to the lack of provision of oral health services, in particular preventive care (See Table I).

The majority of the residents considered the format of the remote dental examination to be either highly appropriate (46%) or slightly appropriate (46%). On the other hand, three residents (6%) were neutral about its format and one resident (2%) considered remote dental examination to be slightly inappropriate. No reason was provided for that view.

When asked about how satisfied they were with the review of oral health needs, although the majority was either satisfied (46%) or slightly satisfied (32%), three residents (6%) were neutral and, more importantly, 16% were slightly dissatisfied. Asked about the reason for this dissatisfaction,

most residents' comments were related to the lack of immediate feedback on the examination.

On comparing residents' opinions on the clarity of the communications received with the face-to-face examiner (i.e., the RN), 86% of the respondents found it "Very easy", and another 12% "Easy" to understand. On the other hand, residents found it generally easy to understand remote communications (46% "Very easy" and 46% "Easy"), and another 4% were neutral about it. Nonetheless, the remainder 4% found it "Difficult" or "Very difficult" to understand remote communications. Residents who found it difficult to understand indicated that the comments were related to the foreign accent of the oral health professional that provided feedback on the examination, rather than the technology used.

TABLE I. RESIDENTS' RESPONSES TO TELEDENTISTRY ASSESSMENT QUESTIONNAIRE (%)

1. How satisfied were you with the remote dental examination?				
Strongly satisfied	Slightly satisfied	Neutral	Slightly Dissatisfied	Strongly dissatisfied
46.0	38.0	14.0	2.0	-
2. If remote examinations were available for patients, would you recommend them to other people?				
Strongly recommend	Slightly recommend	Neutral	Slightly not Recommended	Strongly not recommend
46.0	46.0	4.0	2.0	2.0
3. How appropriate was the format of the remote dental examinations?				
Very appropriate	Slightly appropriate	Neutral	Slightly Inappropriate	Strongly inappropriate
46.0	46.0	6.0	2.0	-
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
46.0	32.0	6.0	16.0	-
5. Were instructions from the examiner in the face-to-face exam clear and easy to understand?				
Very easy	Slightly easy	Neutral	Slightly Difficult	Very difficult
86.0	12.0	2.0	-	-
6. Were instructions from the examiner in the remote examination clear and easy to understand?				
Very easy	Slightly easy	Neutral	Slightly Difficult	Very difficult
46.0	46.0	4.0	2.0	2.0

Over one quarter of the residents (28%) commented that the most valuable element of the remote dental examination was its convenience. For example, by taking video images in the RACF, residents could avoid the disruption, difficulty and cost of arranging travel to visit a dentist.

Three of the five RNs that had been recruited and trained conducted intraoral examinations with the RACF's residents. Nonetheless, most of the exams (n=28) were conducted by an oral health professional. In another eight examinations, RNs were assisted, either remotely or at the RACF, by an oral health professional on how to properly manipulate the

intraoral camera and transmit video images. The RN performed the examination and could transmit the videos by themselves without supervision in 14 examinations (See Table II).

These three nurses 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. RNs also agreed that the length of the material was right. The information about oral health in older adults was considered too long and less relevant to their work.

TABLE II. NUMBER OF TELEDENTAL EXAMINATIONS COMPLETED BY INTRAORAL CAMMERA OPERATOR

RACF <sup>a</sup> Location	Examinations			Total
	Nurse no supervision	Nurse under supervision	Oral health professional	
Urban 1	6	4	11	21
Urban 2	4	0	3	7
Rural	4	4	14	22

a. Residential aged care facility

However, when asked about the relevance of the teledentistry model in their workplace, they were neutral with some indicating that teledentistry might only be relevant to low-care residents, as the model may not be practical in high-care due to dementia and decreased physical capability.

## V. DISCUSSION

The present study tested the technical feasibility and acceptance, by both users and residents, of an alternative model to the traditional face-to-face oral health examination using a teledentistry installation. The results provided evidence that the proposed approach for oral health screening proved to be feasible and reliable as an alternative to traditional oral health examinations. On one side, the observed concordance of remote and face-to-face exams was high. On the other hand, residents expressed acceptable levels of satisfaction with the teledentistry model.

The 'virtual dental examination' can provide general and specialist oral health care support to local aged care facilities. It can assist in providing regular and timely oral health checks using trained non-oral health professional assistants in the first instance.

Additionally, there is anecdotal evidence from RACF staff that the stress imposed by travel to a dental surgery can lead to complete non-compliance with the dental examiner, to the point where attempts at oral examination are abandoned. This leads to further travel and dentist re-booking costs and often reluctance on the part of resident and practitioner to repeat the process. By using the teledentistry approach, RACF avoids the disruption and difficulty of arranging travel for the patients for dental treatment. A successful translation of this technology into clinical practice would extend the provision of health care/oral health care to remote and difficult-to-serve locations, and improve access

for care to additional patient populations at a reasonable cost, as well as easing the shortage of oral health professionals.

The ability to view examination results at their desktop will enable oral health professionals to see and screen more residents per time unit in their catchment area. Further development of the procedures is warranted to allow for high-care resident assessment. Specialist dental services can subsequently be provided when the required treatment is identified.

Oral health professionals will also be able to triage and prioritize appointments, rather than travelling to each home without knowing beforehand what treatment each resident will require. Visiting domiciliary oral health professionals will be aware of the exact nature of the oral problem before they arrive. The oral health professional will also be able to plan a visit to treat other residents in the area, improving efficiency and meaning that more residents are able to be treated over the course of the year. The oral health professional will also be provided with better means of identifying older adults who require a diagnostic examination by a dental specialist.

Furthermore, by performing an in-RACF examination, the confidence that both the residents and the residents' families have in the RACF will increase. From the health care system and societal perspective, a key impact will be in the satisfaction of knowing that residents have been well looked after, and that scarce resources are being well utilized. Additionally, the case for extension of funding would be bolstered. It will improve oral health for underserved communities through education, diagnosis, treatment, health promotion and disease prevention.

Data collected from this project could also be useful as a starting point for a large oral health record repository, which would combine a digital record with 2D and 3D stills and video images, as well as radiographs.

Additional research should explore and address some technical and training aspects of this study, as means of further verification of this approach. Firstly, when the interaction during the conventional face-to-face exam and remote communications was examined, there were significant differences between remote and face-to-face consultation. The face-to-face, provided a more effective mean to achieve clarity and easy to understand communication between the oral health professional and the resident. In the present study it appears that this was due to language and not technical aspects, but this was not explored. However, King and his collaborators [11] reported diminished quality of communication with videoconferencing. Secondly, although adequate training and material compensation to the RACFs for the RNs time was provided, some still failed to fully engage with the study despite the successful use of RNs in other areas of dentistry [12,13]. The perception that this technology is of limited use in RACFs could explain, at least in part, the willingness to take up this new technology [14]. In any case, it seems that barriers to implementation are mostly human factors. Further training and analyses of how different types of constraints operate to support or undermine the adoption of a teledentistry model need to be explored and addressed.

## VI. CONCLUSIONS

Findings for this field trial indicate that using a teledentistry installation is an appropriate alternative to traditional oral health consultation, and could provide benefits to an expanding segment of the population in relative and absolute terms. This population comprises older people living in RACFs and older people living in regional, rural, and even outer-metropolitan areas.

An increasing proportion of older people are living in rural and regional Australia and these communities are demographically ageing more rapidly than their metropolitan counterparts. Intervention projects such as the present one have the potential to target the rapidly expanding aged segment of the population with special oral health needs. There is also potential for wider scale application for the provision of sustainable oral health care in rural areas. Nonetheless, involvement of a wider range of stakeholders might be necessary, as they all influence adoption. Recently, a review of factors influencing the implementation of teledentistry, highlighted some challenges at different levels [14]. These challenges need to be specifically targeted.

This study will lead to a multi-State, community-based trial of the technology. This will require further research into the acceptability of teledentistry by participants, including the format, content and delivery of the program, as well as the relevance and appropriateness of the information provided.

Further research will also be required to undertake economic analysis and modeling to determine the interventions productivity compared to the traditional model of oral health examination.

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