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Telehealth Innovations in Remote Healthcare Services Delivery

Global Telehealth 2020

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IOS Press

The need to promote academic activities in telehealth remains a high priority as the discipline expands into new areas of healthcare. Response during 2020 to the COVID-19 pandemic has provided an excellent example of the rapid diversification and impact attainable with telehealth, and may kindle a new momentum for accelerated service design and adoption processes in the future.

This book, *Telehealth Innovations in Remote Healthcare Services Delivery,* is the tenth in the Global Telehealth series. Due to the prevailing COVID-19 pandemic and the restrictions placed on academic gatherings, the organizers issued a general call for contributions, with the intention of attracting a wide cross-section of contributions reflecting the breadth of different aspects of telehealth internationally. The resulting collection offers snapshots of research projects and studies of service experience from five continents, with an emphasis on delivering benefits in regional settings in keeping with the theme of the book's title. Articles range from descriptions of telehealth networks and clinical-service instances such as cardiac health, mental health and pathology, several in Pacific-rim settings, to more generic papers on the evolution of such services, as well as commentaries on innovative considerations for telehealth such as the emergence of the concept of virtual care, the suitability of health apps, and the status of eHealth readiness in the developing world.

This book is a valuable contribution to the body of knowledge on current telehealth research interests and trends, and will be of interest to all those working in the field.

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TELEHEALTH INNOVATIONS IN REMOTE HEALTHCARE SERVICES DELIVERY

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Preface

This Global Telehealth 2020 volume marks the tenth year for the series, which was conceived in 2010 with a regional academic meeting held under the auspices of the Australasian Telehealth Society. The series has evolved since then to take on a somewhat different character each year, sometimes based on formal conference events such as a track or satellite of a major international meeting, and sometimes based on specialist workshops convened on contemporary topics of interest. Cooperative organisation of these events has been undertaken with the support of a variety of professional bodies, including the International Medical Informatics Association through its Telehealth Working Group and its Asia-Pacific regional arm, as well as several of its national member societies, and also the International Society for Telemedicine and eHealth.

This year necessitated a different approach due to the prevailing COVID-19 pandemic and its severe impact in restricting normal academic meeting activities. After exploring several virtualised options, it was decided that a conventional conference model would not be feasible. Instead a general call for contributions was issued, with the intention of attracting a wide cross section of contributions indicative of the breadth of different aspects of telehealth internationally, and especially targeting many past Global Telehealth sources which have continued to contribute productively in the expansion of telehealth theory and practice. We were encouraged and supported in this endeavour by numerous colleagues from the IMIA Telehealth WG who provided many members of the expert reviewer panel. We also benefitted from new collaborations within the Asia-Pacific region, fostered through several active telehealth interest groups associated with the University of Hawai'i.

The resulting volume offers a number of snapshots of research projects and service experience studies, from projects in five continents: Africa, Asia, Australia, North America, and South America. There is an emphasis on delivering benefits in regional settings, following the book theme of "Telehealth Innovations in Remote Healthcare Services Delivery". The contributions range from descriptions of particular telehealth networks and clinical service instances such as cardiac health, mental health, pathology, several of these in Pacific rim settings, to more generic direction and position papers on the evolution of such services as well as some commentaries on innovative considerations for telehealth such as the emergence of the concept of virtual care, the suitability of health apps, and the status of eHealth readiness in the developing world.

We hope that this volume continues to add to the body of knowledge on current telehealth research interests and trends through the broad sample of cases provided here. The need to promote academic activities in telehealth remains a high priority as it expands its influence in new areas of healthcare. Although not selected as a direct topic for this book, the COVID-19 pandemic response has been an excellent example of the rapid diversification and impact attainable with telehealth, and may kindle a new momentum for accelerated service design and adoption processes in the future.

We acknowledge the substantial financial and in-kind support provided to this endeavour by the Flinders Digital Health Research Centre at Flinders University Tonsley Campus, Adelaide and by the Pacific Basin Telehealth Resource Center at University of Hawai'i Manoa Campus, Honolulu. We also thank the members of the international review committee for their thorough and insightful critique of the papers submitted and in making the final selection of those included on a peer review basis.

Anthony Maeder, Christina Higa, Maayken van den Berg and Claire Gough
Global Telehealth 2020 co-Editors

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Contents

Telehealth Innovations in Remote Healthcare Services Delivery
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TeleCOVID-19: A Multifaceted Strategy from a Public Brazilian Telehealth Service During the COVID-19 Pandemic

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Abstract. The COVID-19 pandemic has quickly and radically transformed health systems worldwide. The challenges are imposed by the need for social distance, remote management of less severe cases, and the constant need for updating health care professionals and the population with reliable information. We aim to describe the experiences and developments of a Brazilian telehealth public service during the pandemic. Numerous tools have been developed and made available, to be used in an integrated manner, by both health professionals and the general public. Those included a *chatbot* for guidance, a teleconsultation platform combined with a telemonitoring system, a teleconsulting service, and a tele-education program. The TNMG services appear to be efficient and robust during the health crisis of COVID-19, through different tools and methodologies focused on both professionals and users of the health systems.

Keywords. Telemedicine, COVID-19, SARS-CoV-2.

1. Introduction

The spread of the SARS-CoV-2 infection has quickly and radically transformed health systems worldwide [1]. In recent years, telehealth's growth has been gradual, but the pandemic has led to an exponential increase, resulting in a rapid adoption of different telehealth strategies. The need to avoid crowding patients in health services and to offer alternative ways for patient assistance while preserving social distancing were compelling reasons for the growth of telehealth [2].

Brazil has the third highest number of COVID-19 cases worldwide, and the second highest number of deaths, with more than 8 million cases, and 200,000 deaths in January

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2021 [3]. In March 2020, the Brazilian Ministry of Health changed the telehealth regulations in response to the pandemic, allowing virtual interaction between healthcare professionals and patients in public and private healthcare, for pre-clinical care, assistance support, consultation, monitoring, and diagnosis [4].

The Telehealth Network of Minas Gerais (TNMG) is a large-scale Brazilian public telehealth service. It was implemented in 2005, providing support to primary care practitioners with teleconsulting and remote analysis of exams [5]. The TNMG currently attends 1,058 municipalities in nine Brazilian states, and has already analysed more than 5.5 million exams and 136,000 teleconsultations in various medical and non-medical specialties.

The TNMG acted quickly to assist professionals and the population in coping with COVID-19, mainly in low resource settings, developing integrated care systems focused on meeting the needs of local communities. Given that the isolation and monitoring of patients and contacts is a major challenge, due to the scarcity of confirmatory tests, community needs are mainly related to community education and management of mild and moderate suspected cases [7].

2. Objective

To describe the multimodal experiences and development of a public telehealth service during the COVID-19 pandemic.

3. Methods

3.1. The TNMG Developments

Several educational and assistance tools have been developed and made available, to be used in an integrated manner, by both health professionals and the general public. They are described in Figure 1, and comprise the following tools:

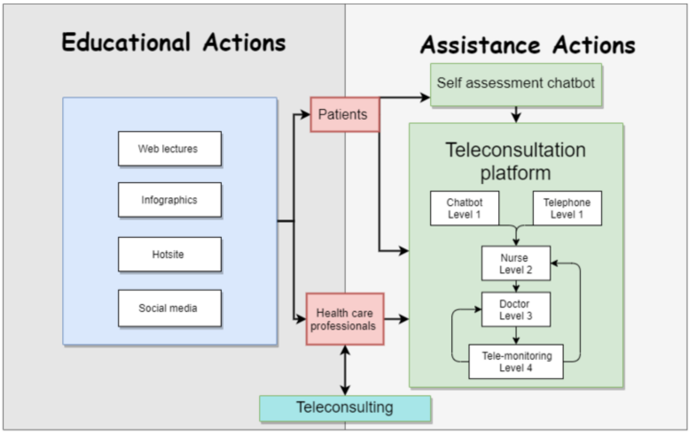

Figure 1. Integrated telehealth actions

- A chatbot and a special telephone switchboard - a multifunction tool developed to clarify doubts about COVID-19, to perform a self-assessment of health status and a gateway to the teleconsultation/telemonitoring program, level 1 of care;
- A platform for teleconsultation combined with a telephone telemonitoring service, providing a comprehensive care with direct contact of the symptomatic patient with a multidisciplinary health team, and a follow-up of the patient and its contacts in home isolation, levels 2 (nursing), 3 (medical) and 4 (telemonitoring) of care;
- A teleconsulting service, for primary care practitioners to clarify doubts, related to specific COVID-19 patients or educational queries, with specialists;
- A tele-education program, including the development of infographics, educational videos and web lectures.

3.2. The chatbot and the special telephone switchboard

The clinical spectrum of COVID-19 is very broad, ranging from a simple cold to severe pneumonia, acute respiratory distress syndrome and death [8]. Based on data from the Chinese Center for Disease Control and Prevention, mild, severe and critical disease was reported in 81%, 14% and 5% of the cases in China [9]. Although asymptomatic infection has been reported, the exact proportion of these cases has not yet been defined. A recent systematic review has shown a prevalence of 20% and 75% in two general population studies, 8% to 50% in three studies with contacts, and 54% among nursing home residents [10]. No study so far has assessed the prevalence of asymptomatic COVID-19 infections in Brazil.

Screening of suspected cases and education of the population is necessary to avoid overload of health services with mild cases, and thus reduce the infection risk. A chatbot was developed to support the screening of suspected COVID-19 cases, as well as to promote education of the Brazilian population on the topic. The development team, composed of clinicians and IT personnel, focused on two key user experience design principles: (i) make it fast and easy for the user, with low technical barriers, without login or app installation, and request minimal user information; (ii) avoid medical jargon, to make it accessible for Brazilians with different levels of education and health literacy [11]. For the screening of suspected COVID-19, a decision algorithm was built by a team of clinicians of the TNMG, based on patients' symptoms, comorbidities, and national and international recommendations [12,13].

The chatbot was developed in BLiP, and is available both through WhatsApp and at the TNMG's website [14]. Two different versions were developed: a stand-alone version, to directly advise and educate the user about general measures and symptom interpretation. As well as a teleassistance version; a digital front door to the teleconsultation and telemonitoring programs.

In addition to the chatbot, in selected cities where the teleconsultation program was being implemented, a special telephone switchboard was developed. The switchboard aimed to cater for the illiterate, those without smartphones, or individuals without the skills to use a chatbot. This telephone switchboard had the same functionality as the chatbot and played an educational role in clarifying doubts about COVID-19, guiding the population on the epidemiological situation, and functioning of municipal health services. Moreover, it also served as a gateway to the teleconsultation service.

3.3. The platform for teleconsultation and telemonitoring of symptomatic individuals

The TNMG developed a specially designed platform for health status assessment and follow-up of individuals with respiratory symptoms. As shown in Figure 1, in addition to the chatbot and telephone front door (level 1), the platform has three more levels of care; level 2; nurse appointments; level 3, medical appointments; and level 4; telephone telemonitoring. An application was developed for use in a web environment. The teleconsultations were carried out by constantly trained doctors and nurses. The software allowed queries by video or telephone, which included the complete evaluation of signs and symptoms presented by the patient, including alarm signs, comorbidities, current medications, personal medical history, allergies, and the screening of household contacts. It also provided the option to make video recordings, prescriptions, medical certificates and reports, for the patient and contacts, as well as to request diagnostic tests for COVID-19, to schedule new teleconsultations, or to refer patients to telephone telemonitoring. Case notification forms and referral forms for health units and emergency services were also available. All the files were generated in a PDF format, so patients could easily download, print and use them, if necessary.

On completion of the medical teleconsultation the patient, if symptomatic and in-home isolation, was referred to telemonitoring. The telemonitoring service was carried out by properly trained medical students from local universities (i.e. telephone calls for patient follow-up), under the supervision of a qualified health professional. They received ongoing training by the program coordinator and made telephone contact with the user every 24 hours where patients presented decompensated comorbidities, pregnancy and puerperium, previous alarm signs or were aged over 60 years. Contact was made every 48 hours in the remaining cases. This service used the same technology developed for the teleconsultation service.

3.4. The teleconsulting service

TNMG has performed offline teleconsultations to support primary care practitioners since 2007. Registered primary care practitioners of 4,931 primary care centers in remote municipalities access the TNMG website [14] via internet and present cases, and, whenever necessary, attach images or other files. Professionals of 46 medical and nonmedical specialties on duty in the TNMG receive the request, analyze it, and respond within 24 hours, or forward the request to a subspecialist, who responds within 48 hours [5]. As an action to support health professionals during the pandemic, a specific category was created for doubts about SARS-COV-2 and COVID-19.

3.5. The tele-education program

The tele-education team worked on various materials to support frontline workers and the general community. Infographics were designed and short educational videos were recorded, directed both to the population and to healthcare professionals. There were also live web lectures about COVID-19, taught by a reference professor in the field. Frequently Asked Questions (FAQs) were developed for healthcare professionals and the general population. All the educational materials produced were made available on a specific COVID-19 hot site on the TNMG platform [14], and all the educational videos were uploaded on TNMG's YouTube channel. Three times a week, short messages related to the topics were posted on Twitter, Facebook and Instagram.

4. Results

The project had to be conducted in an extremely tight timescale and the service and educational program was made available for use in just two months after the start of development. All resources were made freely available on TNMG's website [14] and social media pages.

4.1. The chatbot and the special telephone switchboard

After the greeting message, the chatbot asked for the user's name, to make a semi-personalized friendly interaction, age, gender, location and contact phone number. Then, the user was asked whether the intention is an assessment of his/her symptoms or access to educational questions and answers about COVID-19. In the first case, the user terms are provided, including the information that there is no intention to substitute a medical consultation. If the user agreed, a sequence of questions was presented. To make the screening process simple and efficient, users were asked first whether they had warning symptoms that may be related to severe disease, then about conditions that may increase the risk of severe disease. According to what was selected in those steps, they were ranked in colors, which corresponded to the risk of complications.

According to the guidelines, dyspnea, hypotension and persistent fever were considered warning signs, and individuals presenting any of these should seek medical care [12,13]. So, these were the first questions presented to the user. In the self-assessment version of the *chatbot*, individuals who reported dyspnea or fainting sensation were ranked as 'red' and advised to seek emergency care as soon as possible. Individuals with persistent fever for more than three days or recrudescence of fever after 48 hours were ranked as 'orange' and advised to seek care in hospital settings.

The clinical guidelines recommend that individuals with comorbidities that increase the risk of severe disease should be assessed in reference centers [12,13]. Users without alarming signs but with upper airway symptoms were then asked about specific conditions, such as: cardiac disease (angina, previous myocardial infarction, heart failure), pulmonary disease (asthma, chronic pulmonary obstructive disease, cystic fibrosis), renal failure or dialysis, previous transplantation, cancer, rheumatic disease (lupus, rheumatoid arthritis or other), diabetes, HIV infection, Down syndrome, use of corticosteroids or immunosuppressants, pregnancy or postpartum and child aged under one-year-old. The individuals with any of these conditions were ranked as 'yellow', and in the self-assessment version of the *chatbot* advised to seek a reference center. Those without alarming signs and comorbidities were ranked as 'green' and received advice about how to deal with the mild disease, home isolation measures, need for rest and hydration. Except for the individuals ranked as 'red', all the other groups were offered the educational session from the chatbot.

The educational session of the chatbot was developed based on eighty-five frequently asked questions, from a database from the TNMG. The answers were developed by a group of medical doctors and professors, based on the best available evidence [12,13,15]. The questions were grouped into 12 topics: general information, virus transmission, COVID-19 symptoms, diagnosis, advice, treatment, house care, hygiene, lifestyle, mask use, pregnancy and pets. The database is constantly growing, and new topics, questions and answers are periodically added.

Currently, two medium-sized cities in the state of Minas Gerais have adopted the teleconsultation service provided by the TNMG, specially developed for the assistance of COVID-19 suspected cases. In these locations, a teleassistance version of the chatbot was implemented, connected to the teleconsultation service. The special telephone switchboard was also implemented in these two cities, as an alternative to the chatbot, providing the same educational and assistance services through trained operators. In this version, the chatbot, or the telephone number, is the front door to the teleconsultation program, called assistance level 1. The user classified as 'yellow' or 'green' is referred to a nurse appointment, the assistance level 2. Whereas the user who fulfills the criteria for 'red' or 'orange' priority is directed to a teleconsultation with a medical doctor, the assistance level 3. Between May and November 2020, 1,212 calls via chatbot and 3,794 via telephone were made in these two cities. The chatbot algorithm is summarized in Figure 2.

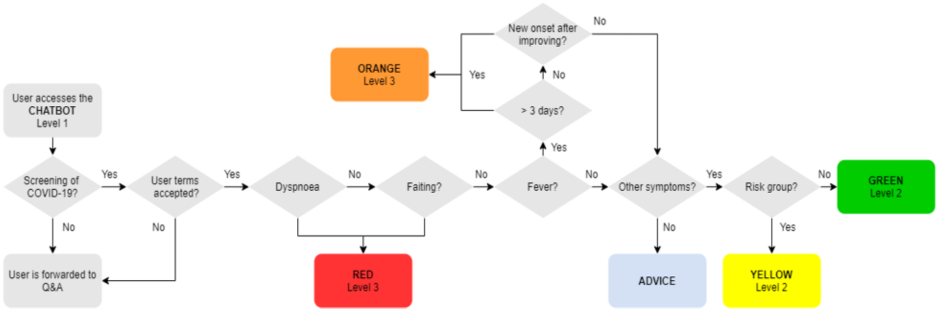

Figure 2. Chatbot decision algorithm

4.2. The platform for teleconsultation and telemonitoring of symptomatic patients

The service has been made available in two medium-sized cities in the state of Minas Gerais: Divinópolis and Teófilo Otoni. Divinopolis is located in the Midwest region of Minas Gerais, Brazil, with a population of 213,016 inhabitants and a human development index (HDI) of 0.76. The public health system is based on Primary Health Care (PHC) supported by Unified Heath System (SUS). This municipality is a health care referral center in a region comprising 54 municipalities. It has three private hospitals and two public, plus one hospital operating under an agreement with SUS and an emergency unit [16]. Teófilo Otoni is located in the Northeast of Minas Gerais, in the Mucuri Valley, with a population of 134,745 inhabitants, HDI of 0.70. This municipality is also a health care referral center for specialized care in a region comprising 27 municipalities. It has three hospitals operating under an agreement with SUS and an emergency unit [17].

The teleconsultation service is being conducted with the support of well-trained doctors and nurses in all the appointments, in close partnership with local universities and municipal health offices in each city. The classification of severity levels is established through the color scale and creates, in specific software, a list of priorities for medical and nursing attendance. All of the consultations occur only after the patient has accepted the terms of consent.

The user classified as 'yellow' or 'green' is first referred to a nurse appointment, level 2 of assistance. The nursing team checks the symptoms and eventual comorbidities of interest through a detailed clinical interview, guiding self-home isolation with telemonitoring (level 4), doctor teleconsultation (level 3), or on-site evaluation in a health unit, in case they deem it necessary. They are also trained to clarify doubts, guide contact tracing and provide advice based on best practice guidelines [12,13].

The user with alarming symptoms who meets the criteria for 'red' or 'orange' priority in the screening is directed to a teleconsultation with a medical doctor (level 3). The professional then checks whether there is an alarming sign and, in this case, refers the patient to an emergency unit. If there is no alarming sign, the doctor can choose to manage the patient through online care only, with other teleconsultations appointments and telemonitoring. Prescriptions, medical reports, and confirmatory testing requests, both for the patient and contacts, are provided.

From May to November 2020, 5,200 attendances of 4,371 patients were made at level 2, and 4,053 attendances of 2,994 patients at level 3. All patients seen in the teleconsultation program, for whom the self-home isolation with symptomatic treatment was recommended, were included in the telemonitoring service of the TNMG, for at least 10 days. In both cities, the telemonitoring service receives patients initially evaluated in the Conventional Health Centers, who were referred to the telehealth service with a direct entry at level 4. Therefore, in the two cities where the program has been established, it has become the main tool for monitoring COVID-19 patients in the public health service.

Patients who were monitored by the telemonitoring team received guidance about the length of isolation, the required restrictions and about how to proceed within contact with other people in the household, in order to minimize the spread of the virus, as recommended by the Brazilian Ministry of Health [13]. They also received advice concerning mental and physical health, such as healthy eating and physical activity. All users are instructed to seek an on-site assessment in case of clinical deterioration or redirected to the teleconsultation program in case of any need.

During the monitoring period, 22,412 attendances were made, monitoring more than 7,000 symptomatic patients in both cities. Preliminary analyses revealed that this number represents more than 90% of the symptomatic patients who entered the system, showing a high effectiveness of the service in reducing the demand of these patients for an on-site evaluation.

4.3. The teleconsulting service

Primary care practitioners from 728 cities in Minas Gerais State could send their doubts about COVID-19 through TNMG's website [14]. The doubts could be about specific clinical cases or general doubts, and an infectious disease specialist answered the queries within 24 hours. If necessary, educational material was forwarded together with the teleconsulting response. From May to November 2020, guidance was provided to 979 queries specifically related to COVID-19.

4.4. The tele-education program

A description of the educational materials produced is shown in Table 1. The educational videos have reached on average more than 108,000 views on YouTube. Six live web lectures about COVID-19 were seen in real-time by 20,000 professionals, mainly nurses (63.8%) and doctors (31.1%), from 45 medical specialties (most family physicians-34.0%), in all Brazilian states, especially the Southeast region (58.5%). Each one of the lectures has reached 5,300 views on average. The hot site has received over 43,000 hits to date.

Table 1. Production of Educational Material

Material	Amount
Short educational videos	21
Infographics	20
Web lectures	6
FAQ	150
Clinical protocols	2

5. Discussion

The development and implementation of multiple integrated telehealth strategies during the COVID-19 pandemic has been a complex and much-needed task. As in other areas, from basic science to clinical trials, the pandemic has imposed a new pace of knowledge building in telehealth, leading to the creation of numerous innovative tools in record time. Such growth is only possible through highly coordinated multidisciplinary work, which involves IT professionals, professors, researchers, doctors, nurses, health managers, local health workers and students.

Several positive aspects of its implementation and operation can be highlighted. First, we must emphasize the alignment with health planning policies and the multidimensional character of the actions [14]. The association of direct health care actions with educational campaigns both for the population and primary health care professionals provides not only a tool that guarantees quality care to the population but also autonomy for users and professionals, with workforce development. The health team of teleconsultation has identified places with possible outbreak of COVID-19 and notified municipalities in a timely manner. Second, centralized coordination, in this interconnected network with multiple collaborators involved, maintains in the TNMG a coordinating center that manages and audits health care, educational and IT development actions, in close interface with municipal health centers. Third, the accessibility of the tools is a key point, both for the simplicity of the devices needed, an instant messaging app or a phone if limited access to the internet, and for the simple and accessible language used. Making it possible to reach a diverse population, of different educational levels. The use of low-cost systems with web platforms allowed for the development of low-cost services in a short time period. Lastly, longitudinal monitoring of patients included in the teleconsultation and telemonitoring system allowed home isolation of patients with the safety of clinical follow-up, necessary due to the sub-acute and prolonged nature of the disease [18]. These actions, contributed to expanding access to timely medical assessment, to the reduction of the proportion of patients in need of on-site evaluation, and to better organize health services. Therefore, it might have contributed to the reduction of virus circulation, keeping at-risk people safe.

The program implementation has also faced many challenges. Unfortunately, due to the urgency of the situation, it was not possible to conduct validation studies of the platforms or software prior to implementation, nor was it possible to involve patients in the development of the self-assessment tools [19]. It was considered an achievement to be able to utilize the platform following a short development period.

The caution to not interfere in local health care networks already implemented and established has been a point of contention. In order to avoid this situation, the local community of health workers and the local university community have been fully involved in the assistance actions. In addition, the alignment of the scientifically based protocols developed by the TNMG with local routines of COVID-19 care, which sometimes did not align, has been a topic of concern. As the information changes and knowledge base expands, there is the need to constantly update the system. Thus, continuous remote training of the team is required, both on the use of the systems and the development of assistance protocols. These challenges have been overcome, and the great integration between the telehealth center and the local health workers community is now the major aspect of the program's success.

Another point of attention has been the lack of resources, especially in one of the municipalities served by the program, Teófilo Otoni. The poor telephone network and the lack of access to internet 4G technology in the city has led to unsuccessful calls and loss of follow-up. Also because of inherent characteristics of the underserved communities, more complex and elaborate platforms that allow, for example, scheduling appointments directly in the system by the patient himself, were not feasible. The platforms developed are particularly appropriate to the general management of COVID-19 in primary care, and not very suitable for handling complex populations in need of highly specialized care. However, this can be a first step towards the incorporation of the technology in other health care settings, as a regular and permanent service.

To date, at the beginning of 2021, Brazil faces an important increase in the number of COVID-19 cases, the services remain in full operation, reaching their peak of activity. Therefore, an objective analysis of the final impact of their implementation is not yet possible and is planned for the upcoming months. In parallel, the user satisfaction will be objectively analyzed, using information collected during appointments.

5. Conclusion

The COVID-19 pandemic is having a profound impact on health systems around the globe. Challenges are imposed both by the burden that severely ill patients bring to the hospital systems and by the need for social distance and consequent remote management of less severe cases. Also, the dissemination of reliable and updated information to the population is a tough and essential task. In the COVID-19 era, telehealth tools have become great alternatives to provide appropriate care to patients. The TNMG services appear to be efficient and robust during the health crisis of COVID-19, through different tools and methodologies focused on both professionals and users of the health systems, with teleguidance, teleconsultations, telemonitoring, teleconsulting and tele-education. Telehealth services should continue to be part of medium and long-term care and become a permanent part of the available supportive resources.

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Telehealth Innovations in Remote Healthcare Services Delivery
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Development and Implementation of Pacific Wide Telehealth Services in Gastroenterology

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Abstract: Gastroenterology, as a sub-speciality in medicine, has been widely developed across the Pacific Nations during the last decade as a result of 'hub' training in Suva, Fiji. Professional isolation for trained pacific gastroenterologists has remained an issue due to the high cost of travel, limited in-country workforce, and recently COVID-19 border closures. Whereas Telehealth solutions have been used for decades across many Pacific Island Nations as a means to improve the clinical outcomes in Pacific Island patients, only recently has this technology been cleverly adopted in fostering education and skill development in Pacific gastroenterology. In this paper, we describe the evolution of these various methods and discuss their use and adaptation in various clinical situations. Herein we consider the future of telehealth programs and the potential for positive impact on Pacific Island healthcare.

Keywords: Distance learning, telehealth, Pacific Island Nations, gastroenterology, endoscopy, instant messaging

1. Introduction

The Oceanic Pacific Region better known as Oceania has a vast land area of over 8 million square kilometres and is home to a population of over 40 million people (1). Oceania incorporates the developed nations of Australia and New Zealand as well as the Pacific Island Nations, with their three main groups Melanesia, Micronesia and Polynesia. These 22 island nations and territories are home to 11 million people and are bordered by vast areas of ocean (2). Due to the vast distances between nations and small populations per island nation, there are significant challenges in accessing and providing healthcare within these small countries (2,3).

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Gastroenterology illnesses are highly prevalent in these regions, including several malignancies and infectious enteric illnesses (4,5,6). Historically, the opportunity for an early diagnosis and treatment of gastrointestinal disease in the pacific islands has been related to limited access to trained professionals, a limited capacity to endoscopy and other diagnostic procedures, as well as the high costs of travel for patients to a referral hospital (7,8,9,10).

In 2008, a centralised 'hub' based gastroenterology and endoscopy training program was developed at the Colonial War Memorial Hospital (CWMH), Suva, Fiji (10). Regional Pacific Island doctors and nurses can undertake specialist training at this centre under the supervision of local and international visiting gastroenterologists, endoscopists and nurses. Over this period of time there have been more than 200 attendances from local and regional doctors and nurses at the centre, many attending for training on more than 1 occasion. This program is celebrated as one of the most successful pacific programs in upgrading technical skills, building capacity and improving knowledge in gastroenterology for Fiji and the Pacific Island Countries. The training centre conducts its program in collaboration with the Australian and New Zealand Gastroenterology International Training Association (ANZGITA) and the World Gastroenterology Organisation (WGO).

As a result of this successful collaboration, there has been wide distribution of skilled gastroenterology clinicians and nurses across the Pacific Island Nations, who now provide access to endoscopy and gastroenterology treatments for Pacific Island people in countries including Timor Leste, Solomon Islands, Federated States of Micronesia (Pohnpei and Chuuk), Marshall Islands, Palau, Vanuatu, Fiji, Samoa, Kiribati, Tuvalu, American Samoa and Tonga. However, once returned to these countries, these upskilled healthcare providers have remained challenged by many factors including professional isolation (11,12). This isolation has included limited access to timely specialist mentor support during clinic appointments and with acutely unwell hospitalised patients, as well as mentor support during elective and emergency endoscopy. Furthermore, there has been an expressed desire to remain up-to-date with pacific relevant gastroenterology knowledge and guidelines.

In order to limit the impact of isolation, several telehealth solutions have been developed and implemented since 2017. The goals of these solutions have been to provide ongoing mentoring and support of pacific island healthcare practitioners in gastroenterology and endoscopy when required. These methods have been locally developed in collaboration with international partnerships and have included monthly case discussions and webinars, instant messaging solutions for complex pacific cases, real-time tele-endoscopy mentoring and case based learning using 'celli-medicine' technology. The overarching principles of these solutions meet the expressed need of Pacific community including curriculum that is sensitive to the local needs, culture and level of technology (13).

2. Development, format and Implementation of Pacific Gastroenterology telehealth seminars

2.1 Pacific Gastroenterology Telehealth Seminar

The Pacific Gastroenterology Telehealth Seminar (PGTS) was first proposed by the authors as a potential solution to professional isolation in education and case support in

2017. During this time there had been a rapid, successful development in novel telehealth solutions in Pohnpei, Micronesia including tele-echocardiography and tele-pathology (14). There were pre-existing global examples of clinical support programs, including Project ECHO, which the authors drew elements from as a model for the PGTS (15). Project ECHO is a novel tele-medicine based strategy based around the 'hub-and-spoke' design and increases knowledge sharing by multiplying expert knowledge beyond a one-one teaching or didactic model and amplifies learning through an all-teach-all-learn model (16,17).

Building on the success of Project ECHO, the PGTS elements include a brief presentation on a gastroenterology focused topic by an international specialist group, followed by a Pacific-wide clinical discussion around the topic, followed by opportunity to discuss relevant or emerging cases. Developing and moderating a group discussion around emerging cases was particularly relevant, as many healthcare problems in the Pacific require a unique understanding of the local capacity to manage the disease as well as a knowledge of disease presentation, which is often different to that seen in the West.

It was considered by the authors that the PGTS could be made widely accessible to healthcare specialists from across the Pacific Nations using pre-existing networks. Much of these networks were already in place as a consequence of the successful work from the Pacific Basin Telehealth Resource Center (PBTRC) Hawaii (18) and through the CWMH Fiji Hub program with ANZGITA (10). The PGTS is made available using Zoom video conferencing facilitated by the host (PBTRC). Invitation to clinicians is widely distributed through email, through instant messenger networks (Viber/messenger) and local healthcare networks via the co-ordinated networks of ANZGITA and the South Pacific Community (SPC) health care subgroup.

Since the inaugural session in 2017, a monthly PGTS has been conducted. The program format includes a welcome and recognition of each attendee, a 15-minute presentation on a gastrointestinal (GI) topic, followed by a group discussion moderated by a central facilitator. Since inception, 25 webinars have been conducted with a broad reaching regular audience including 20-30 individuals from clinical teams from American Samoa, Samoa, Tonga, Fiji, Marshall Islands, Chuuk, Pohnpei, Palau, Kosrae, Yap, Guam, Vanuatu, Solomon Islands, Australia, New Zealand, Hawaii and Canada.

The curriculum for presentation is regularly discussed and planned with the authors of this paper, to ensure that presentations remain focussed on the needs of the Pacific Island healthcare professionals. The small group nature of the PGTS facilitates discussion between healthcare practitioners, and allows for meaningful practical outcomes to clinical cases discussed. Furthermore, the context provides a safe, friendly and open platform for discussions so that healthcare practitioners feel welcomed and valued to express their opinions which enhances the discussions.

2.2 Connecting small networks by instant messenger app to promote case based learning

Whilst the PGTS provides a regular, scheduled monthly gathering to discuss and learn from a wider group of clinicians, prior to 2017 there was no capacity for fast trans-Pacific discussions and education on interesting or relevant cases. In recognition of the successes of the discussion network of the PGTS, we developed the Pacific Internal Medicine Grand Round (PIMGR) using instant messenger facilitation. By 2017, most Pacific Clinicians had access to a mobile device, and would regularly use Viber ™ as a method to communicate within their healthcare network.

We postulated the creation of a huge Viber clinical network, where clinicians from the PGTS would join and post in discussion, would facilitate a regular e-learning network. The PIMGR became the primary platform for a central discussion site on challenging or interesting cases in Internal Medicine including peptic ulcer disease presentations through to Fish Poisoning and pulmonary disorders.

Unlike the PGTS, where a scheduled and planned educational session was conducted, the PIMGR took advantage of an opportunistic moment in medicine, such as at the time of clinical contact with a patient, or during a challenging GI procedure. Since inception, the PIMGR has had over 50 case posts and discussions, most of which have assisted the clinical outcome of the patient.

Due to the success of the PIMGR, there have been several sub-groups developed in order to discuss even more relevant or specific disease processes. These have included an endoscopy focused subgroup in the Solomon Islands, a gastroenterology subgroup incorporating Pohnpei, Fiji and Australia, and a surgical subgroup incorporating Fiji and Australia surgeons.

2.3 Use of telemedicine in emergency endoscopy, Samoa

Samoa is a remote Polynesian island nation with a population of approximately 200,000. Endoscopy re-emerged in Samoa during 2016 following a brief period of use in the late 1990s. The initial experience of endoscopy in Samoa was short-lived due to a lack of ongoing support from abroad and limited capacity to perform the procedure on island (19).

Several trained endoscopists (surgical and medical) and endoscopy nurses have returned from the Suva hub training in Fiji to work in general medicine, general surgery and nursing since 2015 and they have recommenced regular endoscopy procedures on a weekly basis as well as lifesaving emergency endoscopy in urgent cases. Subsequent training for these health professionals has been carried out in country on an annual basis since 2017 by members of ANZGITA. Over time there is a gradual evolution of clinical competency, including disease recognition as well as theatre capacity through equipment support and maintenance. However, a need for a more regular mentorship, particularly pathology recognition and disease management has existed.

Within the endoscopy suite at Tupua Tamaese Meaole Hospital, Samoa, there is no access to fast internet. This prohibits the capacity to truly perform ‘live streamed endoscopy’. To overcome the barrier of isolation during endoscopy, Samoan clinicians have become accustomed to using their own mobile devices installed with instant messenger apps (mainly Viber) to send video, photo and case reports to mentor endoscopy specialists in Australia, New Zealand and Fiji. On receipt of this message the specialist has been instantly able to advise on diagnosis and management options, mostly whilst the procedure is being performed in Samoa. In most cases, this has led to a change in management thinking or a different strategy for negotiating a skill difficulty.

More recently, this strategy had the spectacular result of saving the life of a Samoan patient with life-threatening bleeding from the stomach. The attending Samoan team had recognised the bleeding pathology but required assistance in performing a skill through the endoscope that would control the bleeding point. Using Viber, a series of live videos were recorded, sent to and remotely accessed by an Australian specialist, who was able to provide near-real time live guidance and advice during the performance of the life-saving measure. The patient made a successful recovery without complication. Without this tele-mentoring approach, this patient would have died from this condition. Since this event, the concept of using an instant messenger assisted endoscopy has grown to be used in more cases in Samoa, Palau, American Samoa, Fiji, Vanuatu and the Solomon Islands.

2.4 Initial experience with tele-endoscopy mentoring, Pohnpei, Federated States of Micronesia

There is a developing global interest in providing tele-mentorship to isolated clinicians in surgical procedures. Tele-mentoring has been recently studied in various laparoscopic surgeries and urological procedures with early positive outcome data, and tele-mentoring has been previously reviewed in upper airway endoscopy (20,21,22). Unlike surgical procedures, the e-mentoring or tele-mentoring during gastrointestinal endoscopy has rarely been utilized and is only now in infantile stages of development and safety assessment. Of particular relevance, and as noted in the Samoa example, many Pacific Island clinicians who perform endoscopy are challenged by recognition of pathology, or assistance during a procedure to a new skill or technology.

Our initial experience with tele-endoscopy took place in Pohnpei. Third author of Pohnpei State Hospital conducted a complex gastrointestinal endoscopy while a panel of experts from ANZGITA and Fiji School of Medicine offered real time advice and guidance by video teleconference. At the same time, other participants (Kosrae, American Samoa, Palau, Fiji and Japan) who joined the telehealth session learned much by observing and asking questions.

To assure optimal video image and teleconference quality, Pohnpei Hospital used a high-definition camera and a new desktop screen so that the Pacific Island partners could be seen by the Pohnpei team during the procedure. The procedure involved the insertion of an endoscope into the oesophagus and stomach and the use of a balloon dilator that was inserted into the scope and through a pathological narrowing to widen it. This is a specialized procedure that is usually done by experienced endoscopist.

Third author was able to receive real time mentoring by the experts who observed and gave advice along the way. Experts were able to advise on what instruments and sizes of instruments to use as well as help with the next steps in managing this patient. The procedure was safely performed, and the patient demonstrated a good clinical outcome. This avoided the need for expensive transfer of the patient off island for the procedure as well as developed the confidence and skill of the third author. Since the inaugural e-mentoring, Pohnpei has conducted several subsequent elective real-time endoscopy procedures with mentoring provided from Fiji and Australia.

2.5 Other programs and opportunities

There are many other examples of telehealth support across the Pacific Island Nations that are noteworthy and valuable to mention. As treatment options for viral hepatitis B begins to be made available across several Pacific Island Nations, there is a need to support health clinicians with treatment dilemmas as well as testing and treatment protocols. A highly valuable zoom-led education and clinical support program in hepatitis B treatment program has been implemented in Tonga, Kiribati and Fiji. This program incorporates education and training modules delivered in real-time online, as well as clinical support at the bedside level.

Since 2009 members of ANZGITA have enjoyed travel to Fiji and conducted a month-long education program in gastroenterology to postgraduate doctors undertaking their Master of Medicine or diploma of medicine studies at the Fiji National University (FNU). The program has consisted of four weeks of lectures and tutorials covering aspects of gastroenterology that are relevant in the Pacific region. During the COVID-19 pandemic of 2020, global travel and access to Pacific Island Nations had temporarily ceased. Many of the postgraduate clinicians remained in their regional countries in the Pacific but were able to continue their studies remotely. To overcome this barrier, the 2020 gastroenterology program was redesigned and produced collaboratively with FNU academic staff and ANZGITA using Zoom as the platform to conduct several academic meetings between Fiji, Australia and New Zealand. The program was then conducted entirely via Zoom by academic clinicians from Australia and New Zealand, facilitated by FNU, and joined by the postgraduate clinicians from Timor Leste, Vanuatu, Solomon Islands, Tonga, Samoa, and Fiji.

Finally, a number of Pacific conference presentations have been delivered using zoom during the past 3 years including 2 gastroenterology presentations to the Pacific Basin Medical Association (PBMA) annual medical conference in Palau and Pohnpei by ANZGITA volunteer academics who would not have been able to attend in person and deliver these critical keynote addresses.

3. Limitations and Future Directions

Whilst many gastroenterology tele-technology solutions that support Pacific clinicians have been widely embraced across the Pacific Island Nations healthcare during the past few years, there is much work that can be done to optimize supportive healthcare.

3.1 Creating digital equity across Pacific healthcare

There is a need for digital equity across all healthcare settings. Whilst much of the U.S. affiliated nations including Palau, Pohnpei and Marshall Islands have advanced tele-health settings, access to telehealth support in several nations is in infancy of development, or unavailable. For example, in Port Vila, Vanuatu telehealth is limited to phone and Viber, with limited capacity for live streaming of endoscopy and webinars due to lack of access issues. Only recently, the National Referral Hospital in Honiara, Solomon Islands has come online with access to high-speed internet in its clinical setting. The remote islands of Kiribati and Tuvalu, similarly, have limited access. Many clinicians in larger nations such as Fiji and Samoa are still limited to use of their own mobile devices for e-support in clinical areas despite high-speed internet capabilities on island.

3.2 Challenges with non-clinical educational professional time

There are also several other broader challenges that face participating pacific island clinicians including access to non-clinical time to participate in webinar-based discussions. The broad time difference from the most eastern Pacific Island nations to the most western is 5 hours, and this creates scheduling challenges the capacity for teams to attend scheduled sessions. The impact of COVID-19 and other illness outbreaks such as Measles, Samoa (2019) at least temporarily reduces available clinical time and teams to participate in group discussions. In fact, during COVID-19, many island doctors have faced the challenge of prioritizing a greater number of ‘available’ tele-education opportunities in their small amount of non-clinical time allocation.

3.3 Ethical Issues and risks associated with tele-gastroenterology

There are a number of important ethical and risk considerations for the clinician participating in gastroenterology tele-medicine. For supportive volunteer clinicians who offer their advice and expertise across nations, there is risk of medical litigation, perhaps even more so during e-mentoring during higher risk clinical procedures such as colonoscopy. Whilst several of these issues are discussed elsewhere (23), there is currently no clear, global guidance or global medico-legal support to these clinicians and in most cases, it remains up to the individual to either accept these risks and seek clarification from their own medical indemnity insurer or decline to participate in the clinical situation.

Despite all of these challenges, there remains great excitement, motivation and clinical need to develop digital technology solutions in support of gastroenterology and endoscopy speciality services beyond 2020. There are valuable emerging opportunities in education and training of sub-speciality gastroenterology nurses, bio-technicians and allied health clinicians, who all provide significant care to patients with gastroenterology diseases. As Pacific Island Nations face the impact of climate change and deal with the healthcare impacts of COVID-19, there will be a greater need to develop and embrace digital technology that facilitates and enhances the capacity to successfully provide collaboration, collegiate support, education and mentorship. The Pacific Island clinicians and their diverse health services are, in many ways, already ahead of the many other nations in this regard.

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Challenges and Opportunities to Advancing Telehealth: US Telehealth Resource Centers' Approach

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Abstract: For the past thirty years, the United States Office for the Advancement of Telehealth has promoted the use of technology for health care, education, and health information services, and funds the National and Regional Telehealth Resource Centers (TRCs) to provide technical assistance to support stakeholder telehealth adoption. To assess the challenges and opportunities for the TRCs to advance telehealth, we reviewed publications, national and regional telehealth strategies, guidance from government agency reports and the TRC websites. We summarized information about the mission, funding and structure of the TRC program in terms of the shared service center model of organizational functioning, followed by a description of the TRCs' recent response to the COVID-19 Public Health Emergency.

1. Introduction

The Office for the Advancement of Telehealth (OAT) was established by the Health and Human Services Administration (HRSA) of the United States Department of Health and Human Services (DHHS) in the mid-1990s [1]. For the past thirty years, OAT's mission has been to promote the use of technology for health care, education and health information services. OAT funds various programs for telehealth network development, research, workforce development and technical assistance [2]. OAT funds the National and Regional Telehealth Resource Centers (TRCs) to provide technical assistance to support stakeholder telehealth adoption in the US [3].

There has been a steady increase in the adoption of telehealth in the US over the years with OAT and other government investments for technical assistance, but also infrastructure, equipment and telehealth program development [4]. For example, the Universal Service Program, administered by the Federal Communications Commission, allocates up to $400 million annually for telecommunication and broadband infrastructure for rural health care providers [5]. The Rural Development section of the US Department of Agriculture supports a distance learning and telehealth program that typically funds end-user equipment at approximately $50,000 - $1,000,000 per award [6].

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Although there have been decades of work in advancing telehealth in the US, there are still varying levels of adoption across the country. Rapid and widespread telehealth adoption, however, occurred in response to the Coronavirus Disease 2019 (COVID-19) Public Health Emergency (PHE) [7,8]. The US government promoted telehealth as a means to meet PHE stay-at-home and social distancing mandates. Health care providers across the country needed to rapidly implement telehealth services, but were often unprepared and lacked the knowledge of what was required. The Telehealth Resource Centers (TRCs) were ideally positioned to help, as they were well established with ten to fourteen years of operational experience in providing telehealth technical assistance at national and regional levels. Thus, the TRCs' organizational structure and experience provided immediate resources for telehealth stakeholders in the US.

This paper will examine the Telehealth Resource Centers' challenges and opportunities for advancing telehealth in terms of organizational structure, range of services and other flexibilities to meet intense and rapidly changing needs for telehealth during the COVID-19 PHE.

2. Methods

To assess the challenges and opportunities for the TRCs to advance telehealth, we reviewed publications, national and regional telehealth strategies, guidance from government agency reports and the TRC websites. PubMed, Web of Science and Google Scholar were searched using the terms "telehealth resource center" and "TRC" for any relevant publications. Literature that focused on the Telehealth Resource Centers was included in our review while literature on other topics was excluded. We summarized information about the mission, funding and structure of the TRC program. The National Consortium of Telehealth Resource Centers' (NCTRC) organizational structure is discussed in terms of the shared service center model of organizational functioning. This is followed by a description of the TRC's recent response to the COVID-19 PHE and an overview of the challenges and barriers faced by the TRCs.

3. Findings

The search on PubMed, Web of Science and Google Scholar yielded very few relevant publications that described the Telehealth Resource Centers. The search term "telehealth resource center" yielded 1,753 results on PubMed, 196 results on Web of Science and 39,800 results on Google Scholar. A review of publication titles and abstracts revealed that the majority of the publications on the three databases were unrelated to the Telehealth Resource Centers. The results from Google Scholar were most promising as the search included some publications from the TRCs themselves. Given the very few publications that met the inclusion criteria, our findings were acquired from national and regional telehealth strategies, reports from government agencies, and the information available on the TRC websites.

3.1. Statutory Authority and Appropriations of the Telehealth Resource Centers

The Telehealth Resource Center program was established by law under the healthcare safety net amendment of 2002 (P.L.107– 251, as amended) that was amended in 2020 by the Coronavirus Aid, Relief, Economic Security Act (CARES Act; P.L. 116-136). By statute, the TRCs are designated to provide technical assistance, generally at no cost, to telehealth stakeholders, including state and local health care facilities, health care administrators, chief financial officers, health care providers and patients [2,9,10]. The main purpose of the TRC Program is to provide expert and customized telehealth technical assistance throughout the US. The TRCs are located regionally to facilitate activities at the local level and to ensure that resources are geographically distributed. This regional aspect also helps ensure cultural understanding and appreciation of the unique populations and issues within each region. The TRCs provide training and support, disseminate information and research findings, promote effective collaboration, and foster the use of telehealth technologies to provide health care information and education for health care providers who serve rural, frontier, and medically underserved areas and populations. The TRCs share expertise through consultations, training, webinars, conference presentations, and a significant web presence.

The Office for the Advancement of Telehealth (OAT), Health and Human Services Administration (HRSA) of the United States Department of Health and Human Services (DHHS) has administered the grant program since 2002, with funds being made available in FY2005. The first cycle of three-year grants started in FY2006 [11]. HRSA telehealth appropriations in FY2020 was $28.5 USD million. This includes the TRCs' funding that has ranged from $300,000 to $325,000 USD annually per resource center [12].

3.2. TRC Organizational Structure

Initially the TRCs were funded through a grant mechanism, but in recent years cooperative agreements have been used. A cooperative agreement is a financial assistance mechanism where HRSA expects substantial involvement with the recipient during project performance. Whereby HRSA can among other things, identify special projects or studies for the TRCs to conduct, participate in planning of strategic direction of services provided by the TRCs and provide input and background on current and future issues.

There are twelve Regional TRCs, with three being funded in 2006 – California Telehealth Resource Center (CTRC), Great Plains Telehealth Resource & Assistance Center (gpTRAC) and Northwest Regional Telehealth Resource Center (NRTRC). In 2009 the Southwest Telehealth Resource Center (SWTRC), Pacific Basin Telehealth Resource Center (PBTRC), South Central Telehealth Resource Center (SCTRC) and Southeastern Telehealth Resource Center (SETRC) were established and funded. In 2010 the remaining TRCs were funded: Heartland Telehealth Resource Center (HTRC), Upper Midwest Telehealth Resource Center (UMTRC), Mid-Atlantic Telehealth Resource Center (MATRC), TexLa Telehealth Resource Center (TexLa) and Northeast Telehealth Resource Center (NETRC). There are two National TRCs: the Telehealth Technology Assessment Resource Center (TTAC) was established in the 2006 funding cycle and the Center for Connected Health Policy (CCHP) in the 2010 funding cycle. An interactive map developed by the TRCs shows the regions covered by each TRC (https://www.telehealthresourcecenter.org/who-your-trc/).

Recognizing that resources needed to be used more efficiently and duplication reduced, in 2017 the TRCs agreed to work collaboratively as the National Consortium of Telehealth Resource Centers (NCTRC). The evolution of the NCTRC is analogous to the concept of 'shared service centers' [13,14]. The concept of shared service center strategy generally has several characteristics to maximize operational efficiency, improve consistency and reliability across different units. Shared service center strategies were typically focused on transactional and routine processes in finance, administration (such as procurement, Human Resources) and IT (Information Technology), however, the main concepts of the theory align with the evolution of the NCTRC. The following features are generally accepted as characterizing SCCs [14].

- **They result as a function of consolidation of processes** to avoid duplication of work and to achieve synergies.
- **Are exclusively engaged in support services** to facilitate core processes of the entity, but are not core processes themselves.
- **A main goal is reduction of costs** by making use of economies of scale.
- **They have a service-oriented focus on clients** to optimize the client experience by focusing on service output.
- **They align with external competitors** to enhance competitiveness by building strategic knowledge, analyzing their own strengths and weaknesses thus illustrating their competitiveness to clients.
- **Each unit is an independent organization** clearly separate from others, with its own responsibilities and management.
- **They are operated like a normal business** managed like third-party vendors that tailor their services to the requirements of their customers.

As a Consortium, the TRCs have accumulated an unparalleled amount of resources to advance telehealth programs regionally and nationally. A charter was created and agreed upon by all TRCs. Important governmental aspects include, among others, the following:

- Each TRC is allowed only one vote on NCTRC issues and decisions are made by majority vote.
- NCTRC holds regular meetings: calls with HRSA and committee meetings, i.e., Metrics Committee, Governance Committee, and Strategic Planning Meeting Committees.
- Small committees can be formed to focus on specific work.
- TRCs agree upon an amount paid annually to the NCTRC and pay invoices in a timely manner.

In terms of administration, the TRCs collectively select one TRC to act as the Consortium Administrator that is responsible for all NCTRC operational duties. The Administrator will act as a main point of contact for communications. The Consortium Administrator is responsible for employing and supervising the NCTRC Project Coordinator (supported by the annual fees noted above). The Administrator processes and houses all contracts for the NCTRC (e.g., NCTRC booths at national conferences). The Administrator administers the NCTRC budget as approved by the Governance Committee and at the end of each grant year, prepares a proposed budget for the Governance Committee to discuss, finalize and approve.

The TRCs are designed for effective provision of technical assistance to health providers so they can efficiently integrate telehealth in their practices. Other studies have reviewed the potential for “shared service centers” for telehealth. For example, Denmark’s SSC project found it important for the health care system to focus on internal operations such as “clinical effectiveness of an intervention, or cost effectiveness of a specific workflow.” However, they found that the enabling role of a shared service center "may be characterized as external aspects, seen in relation to the individual telemedical initiative, as they create value on more general levels, such as scalability of services, cross-sector cooperation, and continuity" [13].

3.3. *Type of Technical Assistance*

The TRCs do not provide direct clinical care, but rather their mission is to:

a. Provide technical assistance, training and support for health care providers and stakeholders
b. Disseminate information and research findings related to telehealth services
c. Promote effective collaboration among TRCs and the Office for the Advancement of Telehealth (OAT) within HRSA.
d. Conduct evaluations to determine the best use of telehealth technologies to meet health care needs
e. Promote the integration of the technologies used in clinical information systems with other telehealth technologies
f. Foster the use of telehealth technologies to provide education for health care providers and consumers in a more effective manner; and
g. Implement special projects or studies under the direction of OAT [2]

In order to accomplish these goals, each of the TRCs is composed of experts from a variety of backgrounds who have been involved extensively in telehealth in a variety of ways (e.g., clinical practice, administration, research, program development), in some cases for well over 30 years. Individually, the TRCs have their websites highlighting their specific areas of expertise and the NCTRC has a central website housing key resources and tools for telehealth program development. At both the regional TRC and national NCTRC levels these experts provide webinars featuring key topic areas presented by TRC members as well as experts in telehealth from around the country and even the world. There are repositories of previously broadcasted webinars that can be freely accessed for future viewing and calendars of upcoming events.

TRC members regularly present at national and international conferences, host information booths at conferences, health fairs and a variety of other venues where healthcare providers, organizations and patients attend. A number of them also publish regularly in research journals and all disseminate information about telehealth via other methods such as newsletters, blogs and social media. They generate white papers, position statements, tools, templates and toolkits that help provide unified and standard language defining various aspects of telehealth. Collectively, they represent a "brain trust" of resources, information, experience and expertise that is unparalleled in the US.

The TRCs provide technical assistance to all types of healthcare organizations and providers. They provide assistance on a wide variety of topics, but some of the more common topics include:

- Needs assessments
- Identifying funding opportunities & helping with grant preparation
- Designing & implementing clinical & administrative protocols
- Assisting with selection of technologies
- Assisting with telehealth licensure, credentialing and reimbursement laws
- Evaluation of program implementation & sustainability efforts
- Market analyses, strategic and business planning

- Information on obtaining third party reimbursement for telehealth services
- How to secure Medicaid waivers for telehealth
- Helping overcome licensure & credentialing barriers
- Incorporating telehealth in health system reform initiatives
- Leveraging health information technology (HIT) infrastructures
- Collecting data & helping craft language for educating & informing legislatures on telehealth regulations & policies

3.4. Telehealth Response to the COVID-19 Pandemic

The overwhelming surge and widespread scaling up of telehealth services happened in the US and globally as a response to COVID-19 public health measures to reduce disease exposure for patients, families and health care staff. The use of telehealth also helped to lessen reliance on personal protective equipment (PPE) when there was PPE inventory shortage concerns.

To facilitate the widespread adoption the US government instituted temporary PHE policy changes and regulatory waivers from the Centers for Medicare and Medicaid Services (CMS). In the US, health care coverage is primarily categorized as public (federal, state) and private (private and self-insured). During the PHE federal policy changes did not always align with state laws. Medicare is a federal program that provides health care coverage for the disabled and elderly. Medicare policy and regulatory changes improved restrictive pre-COVID-19 telehealth reimbursement, increased the eligible provider and service type for telehealth reimbursement, waived or reduced patient co-payments, and allowed patients to be seen from home (rural or urban) instead of in a previously required rural health care setting. The US states and territories have oversight of Medicaid, private and self-insured coverage. Medicaid provides health care coverage for low-income beneficiaries. Although the regulatory and policy changes were primarily geared towards Medicare, states often followed the changes for Medicaid and private payor insurers. Legislative and regulatory changes were made at unprecedented rates in terms of the number of changes and frequency. A major role of the TRCs was to help track these changes at a national and state level.

As part of the CARES Act funding each TRC received $828,571 USD in FY2020 to meet the extraordinary increase in technical assistance demands [12]. The TRCs across the country worked together to scale-up technical assistance in response to the COVID-19 related telehealth surge. Each TRC experienced a significant increase (often more than doubled) in technical assistance requests, especially with respect to basic issues, such as, what technology to use, how to start a program, what were the changes in policy, and perhaps most commonly, what codes should be used for billing. The TRCs also experienced a significant increase in the number of organizations requesting training webinars and ready-made materials (e.g., consent templates) for rapid implementation. The number of patients reaching out for information about telehealth also increased dramatically, resulting in an increase in webinars and the creation of COVID-19-dedicated resource materials available on the NCTRC and individual TRC websites.

4. Discussion

The strengths of the TRCs have proven to be numerous, especially during the COVID-19 PHE. They have organized technical assistance to all states, US affiliated Pacific

Island territories and freely associated states via the Regional TRCs and have been especially useful with respect to helping clarify the fragmented nature of US policies at the state level and sometimes at the federal level. The true value of the regional TRCs is the fact that the US is incredibly diverse in terms of geography and unique populations (e.g., Native Peoples) within each region. Each TRC has in-depth knowledge about telehealth and healthcare in general in their regions and has established connections and collaborations with communities of all types within their regions. This regional knowledge builds trust in TRC services and aids in expanding their technical assistance networks and ultimately their impact on patient care as they understand and appreciate health system resources and infrastructure, culture, language, expectations and local and state regulations and policies. The national TRCs are trusted sources for vendor neutral technology review and evaluation and the go-to experts for tracking federal policies as well as providing regular updates about state policy with a semi-annual summary guide of the nation's most current Medicaid provider manuals, applicable state laws, and telehealth-related regulations for all fifty states and the District of Columbia.

The NCTRC adds a layer of collaboration that creates a nationwide network of information and contacts that makes it easy to share best practices across the country and serve as a mechanism for TRCs to reach out and provide resources and support to each other when additional information on a topic is required. The Consortium also allows for increased efficiency through joint webinar production, tool kit development, infographic creation and joint hosting and staffing of booths at conferences. All of these collaborative activities not only reduce redundancies and increase efficiencies, but serve as a cost-saving mechanism as well. In addition, the collaboration fosters collection and curation of information across the country through joint surveys, best practices and related efforts to create a unified picture of telehealth use and progress at the national level.

Despite the efforts and strengths on the TRCs over the years, there are still some challenges that they face. Requests for services and the types of organizations who reach out have increased with each year of the TRC existence. This increase was especially substantial during the COVID-19 pandemic and will likely continue afterwards as practices adjust to expiration of the COVID-19 waivers. Additionally, there has been a significant new focus on direct to consumer, patients and families with associated information requests from these groups. Although all this increase in technical assistance requests is desirable, as it demonstrates that telehealth is growing, funding levels have remained stagnant since the inception of the TRC program (with the exception of CARES funds which are for only one year). Since the TRCs are federally funded, they are also required to submit competitive applications for each funding cycle, thus there are no guarantees that a given TRC will be funded. If a new organization receives a grant as opposed to an existing TRC there is also no requirement from HRSA that they join the NCTRC, although they are encouraged to do so. This lack of potential continuity and consistency could negatively impact the NCTRC structure and the quality of services provided within each region.

Other telehealth barriers include systemic challenges for telehealth adoption. For instance, digital inequity in terms of access to broadband, devices, and digital literacy for health can prevent telehealth adoption. The TRCs are involved in digital equity and digital literacy working groups and task forces, but these groups are often not exclusively focused on telehealth. COVID-19 highlighted major disparities and we need to be careful that increased access to telehealth does not widen these existing disparities. In terms of policy, the TRCs have experience and expertise in all aspects of telehealth and regularly serve as telehealth advocates. The TRCs are prohibited, however, from government advocacy since they are funded by federal grants.

In conclusion, the NCTRC and its member TRCs represent a unique model of telehealth assistance in the US and can perhaps be used as a model globally. Given the various backgrounds and expertise of the NCTRC members, they are poised to meet the challenges of the changing landscape of telemedicine in the future and the implementation of new and developing technologies to better impact patient care and the health of the US.

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The Design and Development of MOVE-IT: A System for Remote Vestibular and Oculomotor Assessment in People with Concussion

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Abstract. Background: Dizziness is one of the most common symptoms following concussion and requires a thorough vestibular assessment. However, due to limited tools and evidence on remote vestibular assessment and intervention, people unable to attend in-person consults cannot receive effective care. **Objective:** This study aims to describe the design and development process of MOVE-IT. MOVE-IT is a mobile phone application with an associated head mount device and clinician dashboard which aims to enhance vestibular assessments and intervention via telehealth by enabling clinicians to clearly observe client's eye movements. **Methods:** This study used a Living Labs methodology including the use of a scoping review, user engagement, multi stakeholder engagement, real-life settings, and co-creation. MOVE-IT was developed in three phases: Exploration, Experimentation and Evaluation. This paper describes the Exploration and Experimentation process. Exploration included a scoping review, focus group and consultation interviews. Experimentation included the co-creation of a minimum viable product in a real-life setting with regular feedback from multi-stakeholders. **Outcome:** MOVE-IT includes three components: a mobile phone application, head mount device and clinician dashboard. MOVE-IT aims to enhance the use of telehealth for vestibular assessments by: (1) using the head mount device to enable video recording of client's eyes during assessment, (2) allowing clinicians to view client's eye movements via the clinician dashboard whilst (3) a support person assists in the physical aspect of the vestibular assessment by a step-by-step guided video in the mobile application. **Conclusion**: The Living Lab method was a useful strategy for developing MOVE-IT. MOVE-IT meets all predefined functionality requirements and potentially provides a solution for remote vestibular assessment and intervention in the concussion population. The Evaluation phase will be conducted next to test usability, reliability and validity of MOVE-IT.

Keywords. Vestibular Rehabilitation, telehealth, mobile application

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1. Introduction

Concussion is a mild traumatic brain injury (TBI) and is responsible for an estimated 70-85% of TBI worldwide [1]. Although it is widely recognised that concussion is underdiagnosed, the projected global incidence lies between 40 and 55 million per year [1]. Most people with concussion recover within two weeks without requiring specialist input [2]. However, approximately 10-15% of individuals experience persistent symptoms 10-14 days after the impact [2]. Dizziness is considered one of the most common symptoms following concussion and a risk factor for prolonged recovery [2-4]. A thorough vestibular assessment is required for these individuals, which involves identifying abnormal eye movements during vestibular testing [3, 4].

During the COVID-19 pandemic, telehealth services were temporarily added to the Medicare Benefits schedule by the Australian Government to maintain physical distancing whilst providing health care services [5]. During this time, there was a rapid increase in the use of telehealth in tertiary Australian hospitals (2,255%), along with primary care physicians to continue providing individuals with health care services when in-person consults were not available [5, 6]. Objective vestibular assessments are challenging to administer using telehealth and there is currently a paucity of literature on individualized vestibular assessment and rehabilitation delivered via telehealth. A significant limiting factor in this area is the inability to clearly observe the client for abnormal eye movements during assessment.

Mobile phones are very commonly used currently in society and various mobile applications have been developed to successfully provide low-cost solutions to assist with health care interventions [7]. Although very few have investigated the use of mobile applications in vestibular assessment and rehabilitation [8-11].

This paper aims to describe the design and development process of MOVE-IT (Management of OculoMotor and Vestibular Evaluation, Intervention and Treatment). MOVE-IT is a mobile phone application with associated head mount device and clinician dashboard which aims to enhance vestibular assessments via telehealth by enabling clinicians to clearly observe client's eye movements during vestibular testing. A mobile application was used, as the general population commonly have access to a mobile device and, when used in combination with a head mount device, it allows free movement of the head and body during vestibular assessments and rehabilitation. MOVE-IT also aims to improve compliance and reliability of maneuver interventions without face-to-face contact with a clinician. This provides potential to progress vestibular rehabilitation at home more effectively.

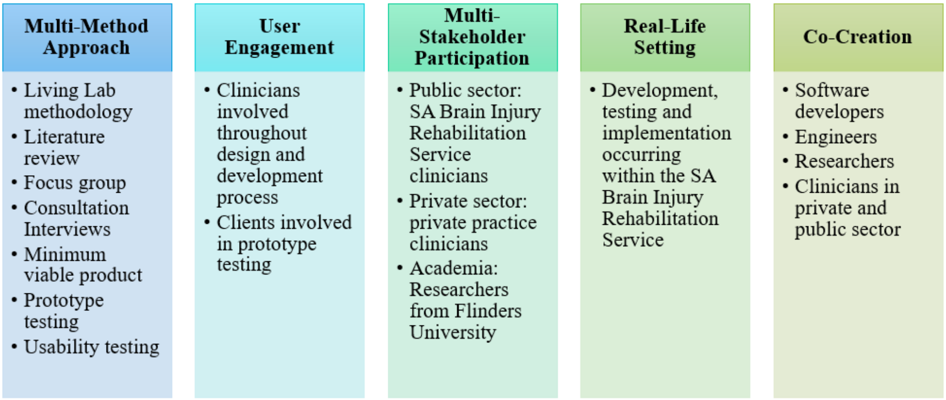
2. Methods

2.1. Overview

A multi-method approach was used to develop MOVE-IT including a scoping review (manuscript in preparation for publication), a focus group, consultation interviews and a minimum viable product.

2.2. Methodology

This study used a Living Lab methodology to enable the creation of a mobile application, associated clinician dashboard and head mount device. The Living Lab methodology focuses on inter-professional collaboration to integrate technical innovations into health interventions [12]. The principles of the Living Lab methodology include co-creation, active user involvement, real-life experimentation, multi-stakeholder and multi-method approaches (Figure 1.) [13]. The phases of the innovation process include exploration, experimentation, and evaluation [13]. The focus on multi-stakeholder engagement in the development process provides researchers and developers with immediate user feedback, improving the likelihood of a successful and sustainable innovation [14]. The study was nested within a larger study evaluating feasibility and effectiveness of an interdisciplinary clinic for people with mild TBI. This study was approved by the Central Adelaide Local Health Network Human Research Ethics Committee (HREC/18/CALHN/365) and funded by Lifetime Support Authority.



Multi-Method Approach	**User Engagement**	**Multi-Stakeholder Participation**	**Real-Life Setting**	**Co-Creation**
• Living Lab methodology • Literature review • Focus group • Consultation Interviews • Minimum viable product • Prototype testing • Usability testing	• Clinicians involved throughout design and development process • Clients involved in prototype testing	• Public sector: SA Brain Injury Rehabilitation Service clinicians • Private sector: private practice clinicians • Academia: Researchers from Flinders University	• Development, testing and implementation occurring within the SA Brain Injury Rehabilitation Service	• Software developers • Engineers • Researchers • Clinicians in private and public sector

Figure 1. Principles of the Living Lab methodology.

2.3. Exploration

2.3.1. Scoping review

A scoping review (manuscript in preparation for publication) was conducted to evaluate the literature for technologies to assist in remote assessment and intervention of vestibular and oculomotor impairments. We searched five relevant databases for studies published in English up to June 2020. Three search strings were used for “Vestibular” AND “telehealth OR mobile app” AND “Rehabilitation”. Two independent reviewers completed initial screening and disagreements were resolved by a third reviewer. Only peer-reviewed journals including interventions able to be performed independently or with remote assistance from a clinician were included.

2.3.2. Focus group & Consultation interviews

Next, a focus group was held to establish the need for a device to assist with remote assessment of vestibular impairment and the necessary functionalities to be included within the system. During the design and development stage, clinicians were consulted as the primary users, as the purpose of the system is to allow a range of specific vestibular and oculomotor tests to occur remotely. The focus group included two occupational therapists and a neurological physiotherapist experienced in rehabilitation of mild TBI. The aim was to establish minimum requirements of MOVE-IT with consideration of minimising potential barriers to usability. Consultation interviews were also conducted with another five neurological physiotherapists and an orthoptist with experience in mild TBI rehabilitation.

2.4. Experimentation

Co-creation was implemented through collaboration with the development team - a team of future users, researchers, engineers, and software developers. The development team collaborated to translate the ideas and minimum requirements from the focus group and consultation interviews into an innovative technology design – MOVE-IT. Weekly meetings occurred between the development team to provide updates on MOVE-IT, to allow feedback throughout the design and development process. A minimum viable product was produced and provided to future users for testing and feedback on the usability of the device. Software developers and engineers encouraged users to trial the device and report any bugs or issues that occurred during testing. This feedback was then taken back to the development team, adjustments were made, and MOVE-IT was updated and provided back to future users for another round of testing. Once a draft prototype has been established, client’s input will be sought as users in prototype testing, to assess ease of use and understanding as well as comfort of the head mount device.

2.5. Evaluation

The evaluation phase is planned for January-June 2021 and will involve clients and clinicians testing the accuracy, validity and usability of MOVE-IT in vestibular and oculomotor assessment and interventions via telehealth in the concussion population. This phase will aim to (1) evaluate if clients are able to correctly follow the guided assessment to produce valid data, (2) determine the accuracy of the data, and (3) whether diagnosis made using the MOVE-IT app provides the same results as in person assessments. Usability will also be assessed in terms of ease of use, ease of understanding and comfort of the device.

3. Outcome

In the following, we present the results of the exploration and experimentation phases of the design and development process of MOVE-IT.

3.1. Scoping Review

The full scoping review will be presented elsewhere. In summary, the study results demonstrated that research on the use of telehealth literature to enable remote assessment and intervention of vestibular disorders is limited. Moreover, no tools were identified to perform a remote vestibular assessment while enabling a clear view of client’s eyes.

3.2. Focus group & Consultation Interviews

Findings from the focus group and consultation interviews reported the inability to clearly observe client's abnormal eye movements as the biggest barrier to remote vestibular and oculomotor assessment and intervention. Also, the maneuvers required for assessment and intervention are difficult to explain to the client or person assisting. Minimum requirements for the head mount device, mobile application and clinician dashboard were discussed with the aim to overcome any anticipated barriers and reduce issues with usability. A full list of inclusions is presented in Table 1. Additionally, a record of assessments and Canalith Repositioning Maneuvers (CRMs) was produced that clinicians wished to successfully perform remotely, requiring a clear view of client's eye movements.

Table 1. Focus Group & Consultation Interview Results – Functionality Requirements of MOVE-IT

Head Mount Device	Mobile Application	Clinician Dashboard
Low cost	Include all required assessments and CRMs	Required to meet SA Health security standards
Easily reproducible	Demonstration video with audio voice over instructions prior to commencement of assessments and CRM	Ability to re-watch videos an unlimited number of times
Not interfere with head position during Benign Paroxysmal Positional Vertigo (BPPV) CRMs	Ability to re-watch demonstration videos before attempting assessment or CRM	Simultaneous video of client's eyes with demonstration video to assess at what point during assessments abnormal eye movements occurred
Light weight to reduce discomfort to the neck	Video and audio instructions during assessments and CRMs	Ability to add tags for ease of search of videos
Clear video of the eyes during head movements	Simple to navigate	
Ability to hold a range of mobile phone types	Available on android or IOS	
Ability to see both eyes once mobile device is attached	Cloud storage to enable ability to send videos securely to clinicians	

3.3. MOVE-IT

The solution to the identified challenges with vestibular assessments and intervention when using telehealth led to the innovative concept materialized as MOVE-IT. MOVE-IT is a three-part system: a mobile phone application, head mount device and clinician dashboard. The mobile phone application was developed in combination with a lightweight 3D printed head mount device which enables video recording of client's eye movements throughout vestibular testing. This allows the client to move their head and body in all directions for various vestibular assessments and CRMs whilst still enabling a clear video recording of the client's eyes. The mobile application directs the support person, such as a family member or friend, with a step-by-step video-guided tutorial, to perform the vestibular and oculomotor assessments. Using the application during the telehealth session allows the clinician to indicate which assessment should be performed and observe or guide the process to ensure accuracy of the assessment technique. The video of the client's eye movements, recorded during the remote consultation assessment, is then sent to the clinician dashboard for diagnosis, and interpreted by the clinician. This enables a higher resolution video compared to real-time video such as telehealth.

3.3.1. MOVE-IT mobile application

To ensure a user-friendly mobile device interface, a minimalist layout was used, as well as a clear step-by-step process to guide users through assessments and CRMs. Due to difficulties instructing the support person to assist with the assessments, initial video and audio voice over demonstration was included, followed by guided video and audio instructions during the assessment. A secure cloud-based storage system was used to allow clients to efficiently send high resolution videos to the clinician, accessible through the clinician dashboard. The mobile application was developed for both IOS and Android to capture both types of devices.

The mobile application begins with a log in and registration page. Once logged in the individual can select the appropriate assessment or CRM as advised by their clinician via telehealth. The mobile application will provide a short video demonstration of the assessment or CRM with option at the end to repeat the video or begin testing. A safety warning appears prior to each assessment or CRM advising users of possible symptom provocation. The mobile phone is then placed in the head mount device and lined up to achieve a clear picture of the client's eyes (Figure 2.) (in the case of an assessment) or comfortably in the middle of the forehead (in the case of a CRM). The support person follows the step-by-step guided tutorial and the clinicians remotely view the process via telehealth to ensure accuracy of assessment or CRM. The video is then sent to the clinician dashboard for remote viewing.

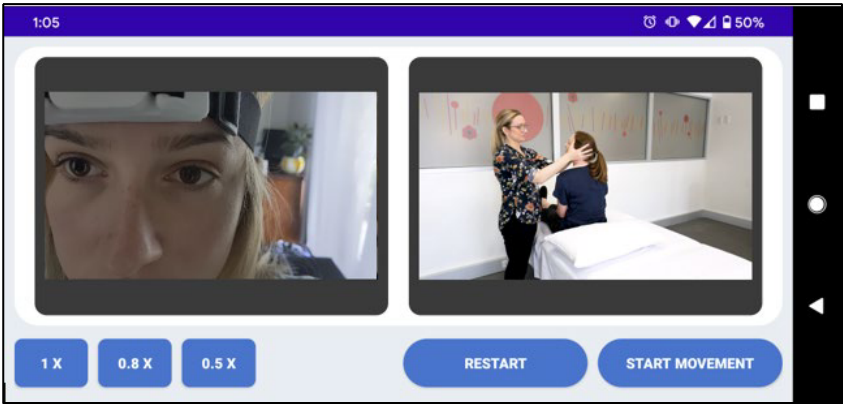


Figure 2. Screenshot of mobile application. Video recording of client's eyes (left), guided video tutorial (right).

3.3.2. Clinician dashboard

The clinician dashboard is accessed through a secured website with an email and password log in. Clinicians are notified by email when a client has uploaded a new video to the dashboard. Clinicians can repeatedly view videos uploaded by their clients to facilitate diagnosis. The eye movement video and corresponding assessment procedure video are displayed in parallel to enable clinicians to determine at what times abnormal eye movements occurred. The clinician can add ‘tags’ to videos to enhance ease of access to search videos later for reassessment.

3.3.3. Head mount device

With respect to the requirements collated in the focus group and consultation interviews, a lightweight head mount device was designed (117 grams) and 3D printed, resulting in easy postage and minimal discomfort to the neck, whilst minimising the cost to reproduce. The head mount device was developed in such way that it can hold a large range of phones, enabling a clear view of both eyes, keeping the front screen visible for the assisting support person. Two head mount device attachments were developed: one included an extended arm to allow a clear view of both eyes, the other sits flat on the head to enable minimal interference during CRMs (Figure 3.). User feedback was incorporated throughout the design and development process. Three prototypes were developed with improvements on size and stability each time following user feedback.

Figure 3. MOVE-IT long arm head mount device on left, short arm head mount device on right.

4. Discussion

In this paper we described the development of MOVE-IT, a three-part system designed to enable remote vestibular assessment following concussion via telehealth using the Living Lab methodology. The Living Lab methodology was used to improve the prospect of a fit for purpose system. Co-creation was achieved within the development team and regular consultation with multi-stakeholders. Users were involved throughout the design and development process in the setting of a mild TBI service, regularly using telehealth. Clients were not included in the design phase, as the issue focused on overcoming challenges clinicians were experiencing with objective assessment via telehealth. Clients feedback will be incorporated following usability testing of the prototype and subsequent modifications will be made as necessary.

To our knowledge, this is the first low-cost device that can enable a clear view of client’s eyes during a remote vestibular assessment when using telehealth. This innovative concept enables clients to receive specialist vestibular input even if they are unable to access in-person consults. Telehealth has been used as a tool to manage concussion in rural areas, although a commonly reported inhibiting factor is limitations in physical assessment [15]. Dizziness is one of the most common symptoms following concussion and requires objective assessments to view abnormal eye movement [2-4].

The Vestibular Oculomotor Screening (VOMS) tool has been performed over telehealth [16] as it relies on subjective symptom reporting however, should not be used in isolation because of limitations related to inter-tester reliability, the possibility of an anxiety component related to dizziness and recall bias [3]. MOVE-IT allows clinicians to view client's abnormal eye movements through objective testing with the use of the head mount device and mobile phone camera. Concurrently, a support person assists the client with the physical component of the vestibular assessment via a guided video tutorial on the mobile application.

MOVE-IT is designed to be implemented by posting the head mount device to clients once they are referred to the service. The clients then download the MOVE-IT mobile application to their personal mobile device. The head mount device and mobile application would then be used during a telehealth consult under the guidance of a clinician to select required objective tests. A support person will assist the client by following the guided video tutorial to perform the physical aspect of the assessment, whilst the clinician supervises remotely over telehealth to ensure accuracy. The video is then sent to the clinician dashboard for diagnosis and interpretation. In cases of BPPV, clients are then able to use the short arm head mount device and guided video tutorial to ensure correct movements are undertaken during a CRM with assistance from a support person.

4.1. Challenges

During the exploration phase, challenges arose around the design and functioning of the mobile application. Using real time video of client's eyes during objective testing in the mobile application was initially suggested. However, this requires high quality internet connection, which is not always available. Therefore, the mobile application was designed to upload the video as soon as the assessment has been completed. Although this may lead to a slightly lengthier consultation session compared to in-person assessment, it aims to provide more accurate diagnostics for telehealth consults whilst removing the time and cost burden of attending a specialist clinic in person. MOVE-IT mobile application uses role models in its demonstration videos and guided video tutorials. As an alternative, animation could have been used, similar to DizzyFix which is a mobile application that guides medical students through an Epley's maneuverer using a guided animation and gyroscope data to ensure correct head position [8]. Animations were not chosen in the development of MOVE-IT as this would have posed additional challenges, increasing costs of development and a lengthier production time.

Several challenges arose during the experimentation phase, when attempting to produce a video clear enough to identify nystagmus and other oculomotor impairments from a smart phone that is moving whilst recording. During testing the head mount device was found to be stable when the head position was upright. However, when the client was required to extend their neck or lie down the head mount device would slip upwards and occasionally off the head completely. To address this issue, an additional strap was added under the chin to prevent significant movement during BPPV testing. Another challenge arose when testing MOVE-IT with CRMs. CRMs require a sequence of various head positions resulting in the arm of the head mount hitting the bed. As visuals of the eyes is not necessarily required during CRMs, this issue was solved by adding an interchangeable short arm to the head mount device to allow the mobile device to be placed closer to the forehead when performing CRMs, to avoid the device getting in the way of the maneuverer.

4.2. Strengths and limitations

A collaborative process was used, involving end-users and stakeholders in a real-life environment, with the aim to reduce challenges and issues in the final product. Scoping previous literature and obtaining clinician perspectives through the focus group and consultation interviews provided insight into prior successes in this area and possible challenges. We developed the mobile application for both Android and IOS, and designed the low-cost head mount to hold most types of phones, improving accessibility.

MOVE-IT is limited in that it relies on a support person with likely little to no experience in vestibular or oculomotor assessment or CRMs. This may result is lower accuracy of assessments compared to an experienced clinician completing the physical assessment in person. Face-to-face assessments allow clinicians to take individuals from an assessment straight into treatment. This reduces the amount of times the client's dizziness is provoked. As use of real-time video was not feasible in this system, individuals are required to complete the assessment, send the recorded video through to the clinician and then complete the appropriate CRM as guided by the clinician, leading to a slightly lengthier process.

5. Conclusion & Future Directions

The living Lab method utilized in this study has been successful in the exploration and experimentation phase of the development of MOVE-IT. MOVE-IT meets all predefined functionality requirements identified in the exploration phase. Once the evaluation phase is complete, we envisage that MOVE-IT will enable remote vestibular assessment and treatment using telehealth in the concussion population. Future studies will start by investigating the validity of MOVE-IT in clinical testing. This will be followed by usability testing with clients and a support person onsite to identify and address potential issues. Following these stages, MOVE-IT will be tested via telehealth with clients offsite in a real-life setting. Following successful testing, MOVE-IT would prove advantageous for vestibular and oculomotor assessments and BPPV treatments for a range of circumstances including individuals in rural and remote areas, individuals unable to tolerate car trips to onsite clinicians, areas limited by COVID-19 quarantining restrictions, assisting less experienced clinicians from offsite locations and sporting teams when interstate or overseas. MOVE-IT may also be extended past the concussion population to other vestibular impairment populations.

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Motivational Embodied Conversational Agent for Brain Injury Rehabilitation

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Abstract. The design and development of a motivational embodied conversational agent for brain injury rehabilitation is discussed. Results for initial prototype design and implementation, and alpha and beta testing phases are presented. Key aspects identified during development included supporting user engagement via personalization and choice-making; integrating behaviour change principles into dialogues; addressing clinical needs of cognitive fatigue and memory loss within conversation structure; and optimizing feasibility of use in a real-life clinical setting.

Keywords. Conversational agent, brain injury rehabilitation, behaviour change

1. Introduction

The design and development of a motivational embodied conversational agent (ECA) for brain injury rehabilitation, named 'RehabChat', is discussed here. A person with acquired brain injury (ABI) may experience complex symptoms both cognitive (e.g. memory, problem-solving) and physical (e.g. strength, balance). Recovery following ABI is often long-term over many years [1]. However, traditional human-delivered rehabilitation services are time limited, therefore novel approaches to care are warranted.

Clients with ABI can benefit from reiterative conversation of important clinical points, particularly goal setting and goal pursuit [2]. Additionally, increased client motivation is associated with improved engagement in therapy and overall clinical progress [3]. Using an ECA during brain injury rehabilitation could support recovery by enabling reiterative motivational conversations about goal setting and goal pursuit, with specific focus upon rehabilitation decision-making processes. Our research aims to investigate whether conversational agent based therapeutic support can be effective in rehabilitation for adults with ABI. Specifically, the ECA will be developed to address time/availability constraints in the health system and/or to provide alternative convenience/motivation aspects for subjects.

We present findings from initial stages of development for the RehabChat ECA, comprising design and implementation of the initial ECA prototype, followed by alpha and beta testing phases. The conversation dialogues in the ECA prototype are configured to include rehabilitation goal-oriented processes and related motivational support, and to accommodate the clinical needs of clients with ABI. The research context is ambulatory

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care rehabilitation for adults with a specific type of ABI, traumatic brain injury (TBI). The ECA will subsequently be refined with focus group consultations and deployed in a pilot trial to establish feasibility and usability, in collaboration with two local brain injury rehabilitation clinics.

2. Developing the Embodied Conversational Agent

The first stage of this project was to develop an initial ECA prototype relevant to the clinical setting of brain injury rehabilitation. This entailed selecting appropriate motivational behaviour change models for incorporation in the ECA, and a suitable ECA software platform. The ECA would be implemented by devising a motivational conversation generation process which followed the main tenets of these adopted models.

2.1. Choice of motivational behaviour change models

Motivation was identified as a central design aspect for the ECA because of its key importance for enhancing engagement in rehabilitation after brain injury [3]. As well, it has been identified that the design of digital health interventions for people with ABI should include motivational aspects [4]. Persuasive techniques are widespread in digital technology design [5] but are not designed for targeting at health purposes, where the subtleties of patient circumstances differentiate them from consumer applications.

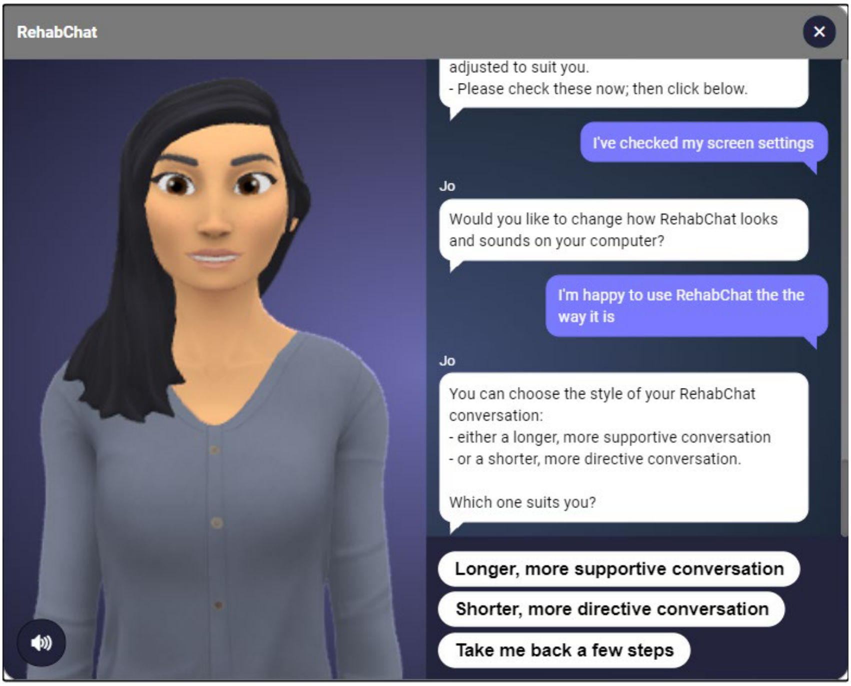
Specific motivational behaviour change models integrated into the ECA were chosen from ABI and stroke literature as ABI-specific literature is comparatively limited, and stroke is a similar diagnosis. The two models chosen were motivational interviewing (MI), a therapeutic conversation approach [6], and self-determination theory (SDT), a theoretical model for key elements of personal wellbeing and motivation [7]. Secondary research review findings show efficacy of SDT [8] and of MI [9] in varied health settings.

More specifically, both MI and SDT have been recommended for brain injury rehabilitation [4] and are compatible between themselves [10]. Benefits of incorporating more than one behavioural change model has been demonstrated for stroke rehabilitation [11], and for use of an ECA for healthy lifestyle choices [12]. Notably, MI and SDT have been adapted for other digital interventions: for example, SDT as the methodological basis for developing person-centred digital technologies [13], and MI as the model used in ECA prototypes for promoting healthy lifestyles [12] and stress reduction [14].

2.2. Capabilities of the ECA software platform

The ECA software selected was Conversagent, a commercial product of Clevertar Pty Ltd https://www.clevertar.com/, based on its affordability and availability of ongoing supplier support. It has previously been used for comparable health purposes e.g. Cognitive-Behavioural Therapy [15]. Figure 1 depicts the humanoid avatar used to provide the embodiment aspect from the chosen software in the RehabChat user interface.

The Conversagent software enables a fully determined, seamless conversation experience to be designed. The avatar speaks the preconfigured conversation content that has been devised for the ECA, and the ECA user interface displays the text equivalent of what has been spoken. The overall ECA conversation can be composed of separate smaller conversations, or sub-conversations. Each sub-conversation is composed of dialogues which are passages or stubs of the sub-conversation. Sub-conversations can be configured to link together as needed. The sub-conversations can be purposed for specific focus areas of the overall conversation. For RehabChat, sub-conversations were developed for distinct areas of goal setting and goal pursuit: for example, choosing a rehabilitation priority to set as the main goal, and practising the home exercise program.



adjusted to suit you.
- Please check these now; then click below.

I've checked my screen settings

Would you like to change how RehabChat looks and sounds on your computer?

I'm happy to use RehabChat the the way it is

You can choose the style of your RehabChat conversation:
- either a longer, more supportive conversation
- or a shorter, more directive conversation.

Which one suits you?

Figure 1. RehabChat user interface showing humanoid avatar and sample dialogue

2.3. Designing the initial ECA prototype

The overall ECA conversation was developed based upon feedback received at two health provider stakeholder meetings held at the collaborating rehabilitation service in 2019, together with the expertise of the first author who has worked in ABI rehabilitation, and also with reference to rehabilitation goal-setting literature [16, 17]. The overall ECA conversation is intended to enable the user to identify and confirm a rehabilitation goal, and relevant home program, through participating in a MI- and SDT-styled conversation.

The ECA prototype dialogues were created using pre-determined language capabilities of the ECA software. Whilst this may seem to be a limitation of this study, the use of constrained language offered the benefit of controlling the nature of the intervention and provided a distinctive form to which the co-design process could respond. Specific technical capabilities of the ECA software which impact upon the development of sub-conversations and dialogues are presented below. Table 1 presents an example of a dialogue string to illustrate how Conversagent dialogues are structured.

Table 1. Example series of conversation dialogues

Content	Components	Follow-on
'Your goal [user name] - next you will develop a goal for your rehab. First, choose a rehab priority below that you'll focus on for the next 6 weeks. It needs to be one that your [therapist/professional] can supervise. : Physical (e.g. strength, balance) : Language (e.g. speaking, reading) : Thinking (e.g. planning, problem solving) …'	A) Pre-set variables : in [square brackets] : auto-populate with freeform text entered by user in earlier dialogue : (in this example) are for user's name and supervising therapist's profession. B) Multiple choice options are provided.	: User selects one option. : Based on user's choice, ECA will jump to next dialogue : For this example, user chooses 'Physical' and is directed to next dialogue shown below.
'Please describe your Physical priority area in your own words. Complete the sentence below: My Physical priority area for the next 6 weeks is ... (up to 10 words)'	A) User is cued to enter freeform text (up to 10 words). : User enters text in text box with a placeholder statement of 'Describe physical rehab priority in own words' B) User clicks 'Send'.	: ECA saves the freeform text entered as a variable [rehab priority] : the user is directed to the next dialogue shown below.
'Why is your rehab priority of [rehab priority] important to you? Please choose an option below. : Increased fitness : More independence : Manage fatigue : Be more connected : Something else'	A) Variable of [rehab priority] populates with freeform text entered by user (see above) B) User selects one multiple-choice option	: If user selects 'Something else' they are directed to next dialogue for entering freeform text to populate variable of [priority's importance] : If user selects one of first 4 options, this wording is saved as variable [priority's importance]

Use of the Conversagent platform enabled various ways to structure how conversations were linked, and how dialogues were created. This flexibility enabled matching to the specific purposes of MI and SDT, for addressing goal-oriented needs.

- Separate sub-conversations for different stages of the rehabilitation process were developed for: goal-setting, identifying support resources; home program details; half-way progress review; final progress review.
- Two styles of conversation content – one with more discursive, supportive dialogues, and the other with briefer, more directive interactions – were designed. For each content style, the full process of goal setting was covered; however, the briefer style had less emphasis on MI and SDT aspects.
- The sub-conversations within each style were linked together using the option to join another sub-conversation. Using this approach allowed for a seamless experience for the user, and also enabled much easier management for the designer as smaller chunks of discrete conversation are easier to edit and review.
- Each dialogue was structured as either a comment or as a question to which the user would respond. User response options were either to select a choice (yes/no, multiple choice) or to enter free-form text up to a pre-designated maximum number of words. Having a maximum word count avoided the overhead of dealing with open-ended unfocussed responses which could cause the conversation to deviate from the model-based overall structure. This approach has been successfully applied in a conversational agent to assess alcohol abuse [18]). Free-form text responses were saved as variables (e.g. user's name, main goal) which could be inserted at relevant points in the dialogues.

Each dialogue is linked to another dialogue by pre-determined logic decisions. A dialogue can be configured to have multiple forward-joining options attached to it. Any of these options is activated according to a set precursor, commonly if the user selects a distinct multiple-choice option.

3. Integrating Motivation and Clinical Paradigms

There were three key paradigms integrated into the design of the ECA. These were motivational behaviour change; needs of clients with TBI; and clinical goal-setting.

3.1. Motivational behaviour change models integrated into the conversation design

Motivational interviewing as a therapeutic conversation model supports the client to reflect upon and articulate their needs/priorities, relevant goal/s, and opportunities and barriers to success. As well, MI is tolerant of resistance to change, and supportive during setbacks in progress [6]. These aspects have been integrated into the design of the ECA through by using a sequence for the questions which follows ideation of a rehabilitation priority, development of a goal, planning for resources needed to achieve goal, practicing required tasks to achieve the goal, and reviewing progress towards goal achievement.

Self-determination theory expounds that there are three inherent human needs of connectedness (relating meaningfully with others), autonomy (opportunity to make decisions for oneself) and competency (perform activities for which one perceives having enough ability) [7]. When these three needs are met, a person is more likely to feel motivated to achieve their given goals. These three needs have been integrated into the ECA through offering autonomous decision-making for goal-setting and in identifying support resources. Competency is supported through ensuring that the goal meets the client's perception of what they can likely achieve in the time period of the intervention, and the type of resources they will need to ensure they have enough support to achieve their goal. Connectedness is promoted by maintaining a regular connection with their key therapist who provides clinical oversight during initial use of the ECA; and through the client identifying a support person to provide them help during their rehabilitation.

3.2. Clinical needs supported in conversational style

The design of RehabChat has been purposefully focused upon meeting the clinical needs of a distinct client group: adults with TBI. Conversational agents have been similarly designed to meet the specific needs of a client group including to provide memory support for memory loss [19], and care for clients with mental health needs [20].

Adults with TBI can experience varied clinical symptoms including pain, fatigue, dizziness, and cognitive changes such as decreased memory and impaired insight. It is imperative that the ECA conversation dialogues avoid exacerbating fatigue, and that they support memory and other cognitive needs. These aspects have been integrated through offering multiple choice options to reduce cognitive fatigue; and providing reiteration and interim summaries of items discussed to support memory challenges.

It is necessary to support the physiological process of neuroplasticity during rehabilitation. Neuroplasticity is the process by which a person continues to develop new brain connections enabling learning of new skills throughout the lifespan [21].

Neuroplasticity following brain injury allows for recovery during rehabilitation; supporting neuroplasticity during rehabilitation is achieved by the client practising motivational tasks [22]. RehabChat provides motivation-based conversation for the user to practise their home program tasks related to their motivational rehabilitation goal.

3.3. Rehabilitation goal setting processes represented in conversation dialogues

RehabChat incorporates key aspects of goal setting [17] and ensuring goals are specific and measurable [16]. It has been specifically designed for clinical rehabilitation, and to be minimally intrusive upon the usual rehabilitation approaches used in the clinics.

- Rehabilitation goal-setting focusses upon client-centred goals formed through exploring the client's clinical needs and personally motivating aspirations for recovery. Clinical oversight is essential in goal-setting to ensure the goals are feasible and safe. This is particularly important when trialing a novel clinical tool. Clinician oversight will be included in the feasibility pilot trial.
- Specific dimensions for rehabilitation goal setting incorporate the components of Specific, Measurable, Achievable, Relevant, Time-limited (SMART) [5]. RehabChat is intended to be pilot trialed in a clinic setting alongside usual care, and to require minimal time and concentration from both the client, and the clinician. These purposes are achieved by matching the ECA dialogues to existing SMART goal-setting paradigms already used within the client-clinician alliance. As in usual practice, the client and clinician will work together to determine specific prescribed exercises to support goal-attainment, which will be practiced at home. These exercises are entered into the ECA and then serve as the basis for subsequent ECA dialogues for times of home practice.

4. Conducting Testing of the RehabChat Prototype

The ECA prototype has undergone alpha (n = 3) and beta (n = 11) testing phases. These results from alpha and beta testing are part of the software development process and are opinions contributed voluntarily by colleagues from the workplace and are not from a research study based on independent recruitment and consented data collection. For the alpha and beta testing, inhouse participants included health professionals familiar with the demographics of typical subjects envisaged and with the use of conversational therapies. Participants were emailed a URL for RehabChat, a User Guide, and a Feedback Form containing specific questions. Participants emailed their response feedback, after using the ECA for a suitable time period (range = 15-30 minutes). Main feedback results from alpha and beta testing are presented below and summarized in Table 2 and Table 3 respectively.

4.1. Alpha testing

The primary purpose of alpha testing was to establish if the prototype ECA was robust, and if it did what it was purposed to do. Five questions were asked:

What went well?
What didn't go well?
What suggestions would you like to make for improving the ECA?

Any other comments?
Could you 'break' the ECA? If so how?

Three senior academic researchers of the Flinders Digital Health Research Centre completed alpha testing. Feedback was collated, and changes were made to the ECA in response to the feedback where feasible. All changes accorded to the principles of MI and SDT and were observant of the clinical needs of clients.

Results from alpha testing confirmed that the ECA software was easy to launch and use. The results also highlighted areas needing to be optimised including supporting client choice-making; allowing personalization of the ECA; and streamlining the conversation structure to minimize cognitive demand. Changes were made to address these feedback points. Table 2 provides an overview of alpha testing feedback and the design response changes made to the ECA. A key change amongst these was the inclusion of a shorter version of the conversation in addition to the longer more supportive version. The updated ECA prototype was subsequently used for beta testing.

Table 2. Alpha Testing Responses to Feedback

Feedback domain	Feedback received	Design response	Reason
Dialogue structure	More multiple-choice to decrease fatigue	More multiple-choice at key decision points	User is aware of expected input; lessens fatigue
Dialogue structure	More variety in multiple choice	Multiple choice options have been diversified	Supports detail in user's thinking, & user interest
Dialogue styles	Use simple language	Simplified to lower secondary school level	Promotes understanding
Personalization	Able to choose a humanoid avatar	Developed 2 avatar styles	Improves personalization
Personalization	An alternative conversation style	2 conversation styles with same main content: longer, supportive style; shorter, directive style	Client preference & clinical need considered
Behavior change	Integrate specific aspects of behaviour change paradigms	Content includes choice-making, meaningfulness of goal, support resources	These inclusions support user's motivation

4.2. Beta testing

The purpose of beta testing was to test the working model of the ECA prototype and seek feedback on the overall concept and its conversation content, particularly in relation to its intended clinical application in brain injury rehabilitation. The Beta Feedback Form was developed based upon software design and client-specific factors. The software factors were derived from the WCAG main principles of Perceivable, Operable, Understandable and Robust [23]. Only the first three of these were applied; the Robust principle was not appraised due to RehabChat not yet being linked to other technologies.

The Beta Feedback Form therefore was comprised of three main sections: Interacting with the technology of RehabChat; Using RehabChat for motivation, goal setting and goal achievement; Potential use of RehabChat alongside usual rehabilitation care. These sections were composed of 12 questions and a fourth section was included for any other open comments. A separate User Guide was developed describing: the intended clinical setting and end-users for RehabChat; the need for clinician oversight; an overview of the process of beta testing; instructions to launch and use RehabChat.

Table 3. Beta Testing: Themes and Main Categories

Theme	Feedback referenced to participant (P) & line number (L)		
Acceptability & usability in clinic setting	Acceptability: non-intrusive (P4, L108); no personal information needed ((P1, L106)	Accessibility: easy to load & get started (P4, L109); only need 'a link' (P3, L99)	Integrate into clinic: 'very easily' (P3, L100); need clinician input (P1, L108); 'I think this could easily be used alongside usual care as an extra support mechanism' (P11, L95)
User experience	Navigation: navigation seems quite intuitive (P11, L23); liked option to go back a few steps (P1, L24); forward backward ok but what if I want to jump a section? (P9, L39)	Typing responses: 'no issues' (P1, L21); user may need help; have more multiple-choice options (P4, L26); typing for me is easy, but I wonder about the BI population? (P9, L36)	HCI: clear, easy to read (P1, L16); easy to hear, good pace (P3, L16);
Motivation & behavior change	Make choices: 'to some extent, when you can enter text, but less so when clicking the response buttons' (P1, L99); to an extent – dependent on relationship with MDT (P8, L51)	Promote self-managing: yes, because user-focused (P3, L107); 'really think about yourself' (P7, L48)	Supports motivation: through goal setting (P2, L63); 'Provides support when needed, helps to set goals and review goals, keeping client motivated and on track.' (P10, L64)
Clinical relevance & use	Communicate with therapist: 'encouraging the user to follow-up with their therapist' (P1, L62); 'if the therapist could see the data entered that would be helpful' (P1, L70)	Support rehabilitation: 'Definitely, clear goals are the focus' (P4, L98); Enables client to review progress – revisit goals. (P10, L72)	Practice home tasks / exercises: 'looks like a good process' (P6, L77); 'need more breakdown of the tasks.' (P3, L74)
Ideas for future design changes	Goal setting: set measurable, specific goals (P5, L99); 'More guidance could be provided in development of goals' (P10, L113)	User interface: 'It would be enhanced with more audio, visual and interactive capabilities if possible.' (P3, L122)	Give feedback: 'More intervals than just baseline, halfway and after the program.' (P3, L60); may need to screen for suitability (P9, L111)
Browser & computer used; ECA performance	Browser: Chrome (9); Safari (1); Explorer (1)	Computer: laptop (5); desktop (6)	Performance: 'Good, no glitches or complications with the RehabChat itself.' (P3, L45)
Technical issues	Avatar speaks some punctuation e.g. says *dash* for - (P6, L133)	Some entered content not populating later dialogues (P6, L31)	Connections between dialogues at times not logical (P2, L174)

Potential participants invited for beta testing were Flinders University PhD candidates or academic staff affiliated with the Flinders Digital Health Research Centre, with experience in digital health technology and/or health care. Participants were requested to choose to provide feedback based on the perspective of either a clinician or that of a client. Eleven individuals ultimately participated.

Participant responses for beta testing were analysed using the Framework Analysis method [24] to develop a cohesive thematic model. This included: making initial coding notes on the completed Feedback Forms; defining likely themes and categories to best fit the coded data; and organizing the data under the themes and categories. Changes to the thematic model were made iteratively during analysis to optimise clarity in how data was organized. Beta testing themes and main categories are presented in Table 3.

Results from beta testing revealed that RehabChat functioned easily for users, and any ECA dialogue issues were the result of content configuration issues. Feedback recommendations for changes regarding clinical application and feasibility included: needing to enhance specific aspects of goal setting; allowing for more choice-making during progress reviews; and providing visual feedback on progress being made.

Following beta testing, the ECA was substantially modified to include more choice making, explicit collection of SMART goal-setting information, smoothing out of the conversation dialogues to read more easily, correcting design errors which had impeded correct linking of dialogues and inputting of variables; and clarification of the user guide and training process for users to receive prior to intended clinical use. This updated version of RehabChat will be used in the subsequent co-design workshops.

5. Conclusion

Early testing of the ECA prototype RehabChat has examined its clinical relevance and potential usability, and identified aspects requiring further development. The appropriateness of the conversation and dialogue structuring and the utility of the two style variants has been confirmed by this process. This testing phase has provided the basis for further intended refinement and extension of the ECA to be achieved through co-design workshops and a pilot trial. The next stages for developing the ECA prototype are firstly, to conduct a series of four co-design workshops with clients and clinicians of the collaborating brain injury rehabilitation clinics; and secondly, to conduct a feasibility and usability pilot trial at the same clinics over a six month period.

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Telehealth at Home: Co-Designing a Smart Home Telehealth System

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Abstract. Increasing life expectancy and rates of chronic conditions place increasing demands on aged care health and support services. One response preferred by older adults and seen as cost effective is aging in place, whereby older people remain in their own homes and avoid aged residential care. For this to take place, it is crucial that older people maintain effective relationships with support networks and that older adults and these networks have adequate information to support patient centred health and wellness care at home. This study explored how smart home telehealth, a form of telehealth where health care is provided at a distance using smart home digital technology (sensors), could assist older people to age in place and enhance their health and wellbeing. It was a two-phase project, preceded by a workshop with experts:1) 41 interviews with older adults and their informal support networks, seven focus groups with 44 health providers working with older adults, which informed 2) a pilot implementation of a co-designed telehealth system, addressing key barriers identified in Phase 1. The system used low cost, easily accessible, and commercially available sensors, transferring information via email and/or text messaging. It was successfully piloted with five older adults and twelve of their respective support networks for six months, who reported an increased feeling of security and improved interpersonal communication. The findings indicate that smart home telehealth could assist aging in place, and the study provides insights into successful co-design of smart home telehealth services at scale that could be implemented and deployed in contexts wider than aged care.

Keywords. Aging in place; smart home technology, telehealth, wellness

1. Introduction

Telehealth is the use of information or communication technology to deliver health or medical care from a distance. Key areas include telemedicine, telemonitoring and mHealth [1]. Smart home telehealth is a form of telehealth monitoring, where telehealth is combined with smart home technologies such as sensors [2,3]. It enables health and wellness information to be collected passively within the home rather than at health care organisations and facilitates the transmission of that information to relevant care providers. It makes the collection and sharing of health and wellness information accessible to a much greater proportion of the population and locations.

Alongside increasing life expectancy in New Zealand (NZ) [4], in line with other developed countries [5], more people are living longer in poor health, with multiple co-

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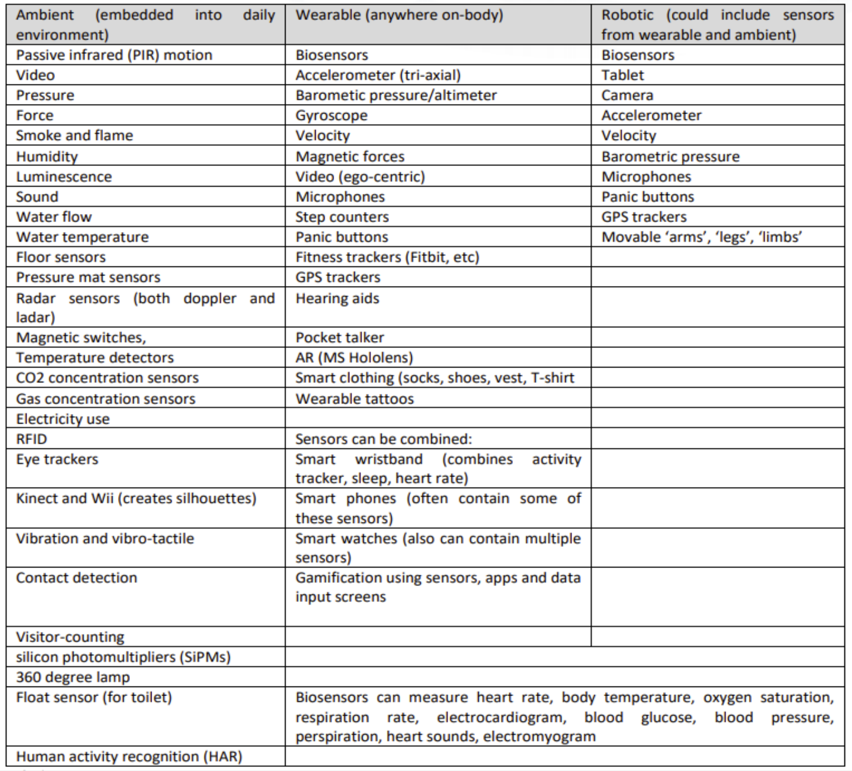
morbidities [6], challenging health systems to provide sustainable health care services. Policy makers in New Zealand strongly support a patient-focused integrated primary care approach in which the older adult (OA) is supported by formal and informal support networks to remain in their community in the place they call home, a policy supported by OAs and known as ageing in place [6-9].

Aging in place is dependent on both informal carers (support networks such as family, whānau, friends, neighbours, etc) and formal carers (health providers). This support by informal carers accounts for 50-90% of the long-term support of OAs [10] and most have limited access to formal support services [11]. The study is underpinned by the Structural Model of Actors developed for this study (illustrated in Figure 1). It emphasizes individualized care by placing the OA at the centre surrounded by two layers of support networks that enable aging in place; an inner layer of informal support networks who provide informal practical and emotional support, and an outer layer of formal support networks, comprising health providers.

Figure 1. Structural Model of Actors

The inclusion of the informal support layer emphasises the increased complexity of these new models of care in comparison to the more traditional dyadic patient-practitioner situation. It explicitly recognizes the changing roles and relationships and information exchanges which take place, including those between the formal and informal support networks, and highlights that these relationships can be separated by distance (and indeed by time). Significantly, as the arrows in Figure 1 indicate, the model would allow one-to-one, one-to-many, and many-to-many communication streams. Telehealth, by its very design, is ideally placed to enable and support these different communication streams. In the model, smart home telehealth systems would enable information collected by smart home technologies to be communicated through digital technologies (laptops, computers, mobile devices, email, texting, video chat, etc), using information communication technologies (wifi, bluetooth, internet, etc) across the different actors.

Smart home technologies have been used to support OAs as they age in place for some time. They may range from simple home monitoring sensors [12] to purpose-built smart homes with complex sensor setups including voice activation and intelligent cognitive assistants [13,14], however the simple basic unit is a sensor. Sensors can be wearable, ambient, or robotic, with multiple sensor deployment, the commonest use of sensors [15]. Figure 2 lists different types of sensors currently available (in no particular order). Hence, it is a potentially complicated field for OAs to understand.



Ambient (embedded into daily environment)	Wearable (anywhere on-body)	Robotic (could include sensors from wearable and ambient)
Passive infrared (PIR) motion	Biosensors	Biosensors
Video	Accelerometer (tri-axial)	Tablet
Pressure	Barometic pressure/altimeter	Camera
Force	Gyroscope	Accelerometer
Smoke and flame	Velocity	Velocity
Humidity	Magnetic forces	Barometric pressure
Luminescence	Video (ego-centric)	Microphones
Sound	Microphones	Panic buttons
Water flow	Step counters	GPS trackers
Water temperature	Panic buttons	Movable 'arms', 'legs', 'limbs'
Floor sensors	Fitness trackers (Fitbit, etc)	
Pressure mat sensors	GPS trackers	
Radar sensors (both doppler and ladar)	Hearing aids	
Magnetic switches,	Pocket talker	
Temperature detectors	AR (MS Hololens)	
CO2 concentration sensors	Smart clothing (socks, shoes, vest, T-shirt	
Gas concentration sensors	Wearable tattoos	
Electricity use		
RFID	Sensors can be combined:	
Eye trackers	Smart wristband (combines activity tracker, sleep, heart rate)	
Kinect and Wii (creates silhouettes)	Smart phones (often contain some of these sensors)	
Vibration and vibro-tactile	Smart watches (also can contain multiple sensors)	
Contact detection	Gamification using sensors, apps and data input screens	
Visitor-counting		
silicon photomultipliers (SiPMs)		
360 degree lamp		
Float sensor (for toilet)	Biosensors can measure heart rate, body temperature, oxygen saturation, respiration rate, electrocardiogram, blood glucose, blood pressure, perspiration, heart sounds, electromyogram	
Human activity recognition (HAR)		

Figure 2. Sensor types [15] (reproduced with permission)

Smart home technologies are often underutilized [16], and there are known barriers to uptake among OAs, including privacy, cost, and unrecognised need [17,18]. Physical and cognitive decline may limit an OA's ability to use technology [16,17]. Wider organizational and financial barriers, and regulatory and legislative issues with adoption of digital health systems exist [19]. Specifically, in New Zealand, culturally safe data collection, data ownership and governance must be addressed [20]. Studies have tended to consider technical aspects of sensor use with OAs or in controlled situations which are unrepresentative of real-life in OA's homes and have not considered human aspects of use [15]. Thus, this study has taken a socio-technical systems approach, which recognizes that the adoption of new technologies involves interaction between society's complex infrastructures and human behaviour [21] and aimed to explore the barriers and user requirements for smart home telehealth systems for OAs living at home and to develop potential solutions.

2. Methodology

This study was a two-phase project, preceded by a workshop with experts, consisting of 1) 41 interviews with OAs and their informal support networks, seven focus groups with 44 health providers working with OAs, which informed 2) a pilot implementation of a co-designed telehealth system, addressing key barriers identified in Phase 1. The study procedures were approved by the Massey University Human Ethics Committee (SAO 16/65 and 17/32). Full details of the methodology and results of Phase 1 have been published elsewhere [22-24]. In brief, participants for Phase 1 were recruited using convenience sampling from people who expressed interest following promotion of the study by several community organisations. Older adults were aged 70 years or older, living alone in the study area (a provincial and semi-rural area) and had at least one chronic condition. Participating OAs self-identified two to four members of their informal support network. Ten OAs and 31 informal support network people participated in Phase 1. Older adults were aged 72-92 years; 8 were female and two male. Informal support network participants were 22-80 years old; 35 were female and six male.

From the Phase 1 participants, five OAs and twelve members of their respective informal support networks (SN) were recruited by convenience sampling to co-design a prototype system for each OA. This paper will focus on Phase 2 - co-designing a prototype smart home telehealth system individualised with each OA/SN grouping informed by the themes and derived user requirements from Phase 1. These user requirements are summarised in Table 1 [22].

Table 1. User Requirements Derived from the Inductive Analysis [22]

Theme	User Requirement
Information Desired	1. The OA should decide what information is collected
	2. The OA should nominate who has access to the information
	3. Different information should be able to different members of the OA's support network.
	4. The system should have the capability to send raw and/or processed data (such as to only send information 'outside of the norm')
	5. The system should be adaptable to the OA's changing needs
Communication Practices	6. The system should supplement, rather than replace, previous communication practices.
	7. The system should use a variety of technologies to connect the OA to members of his or her support network.
Technology acceptance	8. The system should be adaptable to the OA's changing needs (also identified from the Information Desired theme)
	9. The system should save the users' time
Privacy and Security	10. The information should be stored and transferred securely.
Cost	11. The system should be low cost.
	12. Whenever possible, the system should utilize objects that are already present within the OA's home.

These requirements were used to inform decisions made during the system design such as selection of sensor types for the project (low cost, readily available, utilise objects already used in the home) and the OA determined which of these sensors they wanted to use, how they wanted them used, what data was collected and to whom it went. Privacy and security user requirements were met by a centralised hub that stored data on an SD card that did not leave the OA's home. Data collected was processed using a Raspberry Pi located within the central hub so that only 'information outside the norm' such as alerts were sent. In order not to impact on an existing phone or internet setup, the central hub also included a private network with a SIM card paid by the project. Open source software was used to keep costs low. Each prototype system was piloted by a member of the research team, and then installed in the respective OA's home. During the six-month trial period, a researcher engaged with OA and their SNs through phone calls, emails, text messaging, and personal visits. Individual systems were further customized by the research team using agile development as the OAs became more familiar with the possibilities around how the systems could support their activities of daily living. Examples of this are the medication reminder which was initiated in the 3rd month (for one OA) or where the initial setup did not meet the OAs requirements, such as the reminder light for another OA with low vision. One system was deliberately located in a rural setting to identify any additional issues due to rurality. For evaluation of the system-system availability, use of transmission networks, email and social media was determined from data traffic collected as part of the technical administration of each system and each OA and each SN completed a semi-structured interview with resultant thematic analysis.

3. Results

3.1. Prototype Architecture

Each system comprised of a smart-lightbulb and/or a multi-sensor (temperature, motion and luminescence) and/or a smart plug as well as a central control hub, which notified the SN members to contact or visit the OA if activities were outside of the norm (as defined by each OA and SN). The SN members utilized a tablet and/or a smart phone to receive messages, which were sent passively (through the sensors). The central control device applied rules to evaluate data produced by the sensors, which could result in a message being sent to designated members of the older adult's support network.

The smart-plug could be activated to inform the control device when the appliance that it was connected to (such as a television or kettle) was turned on by the older adult (the devices selected were individualized to the OA). The sensor could inform the control device when it detects movement by the older adult (the locations of the sensors were individualized to each OA). The hours that these technologies functioned were also individualized to each OA. The smart-lightbulb could change colour to notify the older adult that there is an alert, such as the oven being left on, the room being too hot or cold, messages being sent to support network participants, and/or appointment reminders. The key aspect of the system was that the monitoring and any generated alerts were passive, the OAs did not have to initiate any action.

The OAs and their SNs had very little awareness or understanding of telehealth or smart home technologies prior to taking part in the study. During the study, as their level of understanding increased, they developed their own ideas for use of these technologies.

Specific design elements raised by participants included each system to be configured according to the OAs self-reported routine and their desire for security; that their SN would be made aware if the OAs routine changed (for example 'they did not come in from the farm in the evening"); for safety, when they had forgotten to turn the element on the free-standing cooker off after one hour; for reminders (e.g. with taking medication) and therefore their SN would be notified of these exceptions to the OAs daily routine. An example scenario is shown in Figure 3 where temperature is tracked between 9am and 9pm with an alert sent to a SN if the temperature rises above 22 degrees.

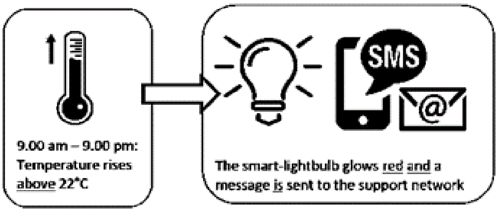


Figure 3. Example scenario

Meeting the user requirements and design elements raised some technical challenges, in particular with 1) interoperability - different sensors used different communication protocols (Wifi, Bluetooth, Z-wave), 2) stand-alone systems - energy efficient with low maintenance requirements, and 3) technical privacy constraints - different layers of communication between OAs and SNs, use of social media, and setting up a private network infrastructure within the home. These were addressed with a typical system consisting of a timer (for events), smart technology (sensors) and services (email, SMS and later Facebook), see Figure 4.

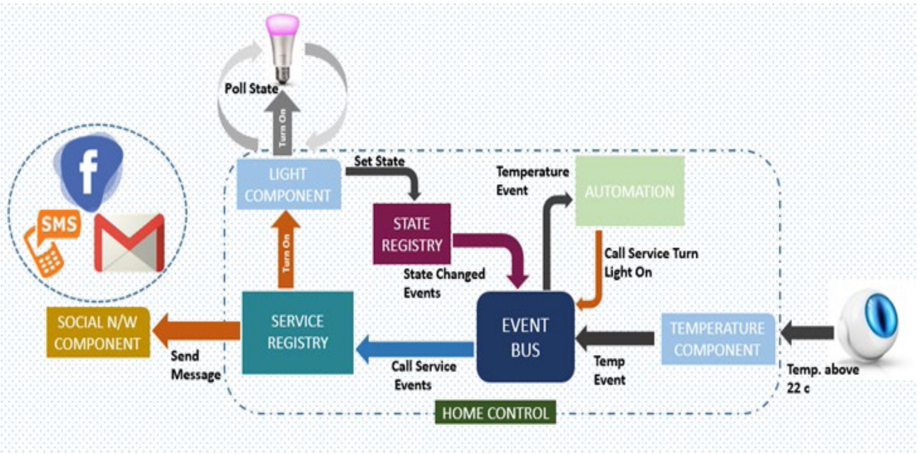


Figure 4. System architecture

3.2. Prototype Evaluation

Two participants were unavailable to complete the final interview due to a deterioration in their health, hence thematic analysis involved 15 respondents (Table 2).

Table 2. Evaluation of prototype system – thematic analysis

Theme	# Respondents who agreed or strongly agreed	Comments	Notes
Improves communication	14/15	*'Yes, we had good communication before, but this made me call him more often if I got a message' (SN)* *'Communication with Mum definitely improved and also communication between her support people' (SN)*	Remaining respondent was neutral.
Enhances Relationships	9/15	*'Yes, it brought my two daughters into the mix when before there was just the friend who I contacted daily' (OA)* *'Yes, I think it did this. My sister and I would text about where Mum was up to if we had texts' (from the system) (SN)*	No-one disagreed and two did not answer this question
Increased my feeling of security for the OA's safety	13/15	*'Yes, knowing it's on as an alert is good first thing in the morning. Plug + multi-sensor setup is ideal' (OA)* *'The system is very helpful as we can't always be there, so if something is out of the ordinary it's comforting knowing that we will be contacted' (SN)*	Two did not answer this question
Overall, I am satisfied with the system	11/15	*'Yes, I have been privileged to be part of this and my boys are very keen to see it continue, they are sad to see a bump in the road' (OA).* *'I miss them' (OA).* *'Worked well. Looked simple, non-intrusive. Was flexible to accommodate Mum's needs' (SN)* Some respondents commented on different parts of the system: *'The multi-sensor was better for me than the smart plug because it monitored both am and pm & because I just walked past it and it knew!' (OA)*	One person disagreed Three did not reply and one was neutral. The *'bump in road'* was stopping project due to lack of funding.

Overall, strengthened relationships and widened networks with reduced levels of loneliness was a key reason for user satisfaction: *"Daily monitoring strengthens our relationship. I like the 'not needing to worry' or feel undue concern"* (SN) *"It got my family involved in the project and expanded my network. It prompted my family to look into technologies that do this and what technologies are existing outside the project. It made me more enthusiastic about technology"* (OA).

The respondent who was not satisfied with the system (Theme 4) had a system that suffered from several technical issues due to rurality which were difficult to work out and solve. This highlights that the main problems experienced with the prototype systems were technical in nature relating to connectivity issues and system resets after power surges and outages particularly with rurality. Using SD cards created problems with some systems but not with others, extensive exploration indicated that SD cards have limited ability to cope with multiple read/writes.

Additional functions were recommended by OAs and SNs such as an emergency option, detecting that the door was locked at night, using the flashing or static smart light, and its various colour options for many different functions such medication reminders or switching off the oven.

4. Discussion

This study explored how smart home technologies that connect OAs to their support networks could assist aging in place and enhance OAs' health and wellbeing. User requirements were identified in Phase 1 (Figure 2) and similar barriers to those previously identified in the literature were found [16-19] along with connectivity, power stability and interoperability. This project has shown that user requirements can be met, and barriers overcome. Scholars have warned against technofixing, whereby technology is proposed as a solution on its own without considering the broader social context [25], which advocates for a socio-technical systems approach [21] to the development of technologies. Although our findings from the prototyping are preliminary, one of the reasons why our system was utilized and positively evaluated could be that it was successfully grounded in the community by connecting OAs to their informal support networks. Furthermore, as the system allowed for individual customization and for one-to-many and many-to-many communication channels, rather than just the traditional patient-to-provider channel, the system could be tailored to the OA's needs, responsibilities among informal support network members could be shared, information needs could be delivered, and privacy could be respected.

At the same time, the possible negative consequences from a disregard of ethical issues should not be overshadowed. The need for the OA to be in control of their information was identified as a key user requirement. This highlights the advantage of being able to customize the system to the OA's requirements, but it also indicates the issue of giving informal support members access to personal information. As they are not registered healthcare practitioners, they are not bound to the same degree of regulation pertaining to the collection, storage, use, and disposal of personal information. Hence governance of this information in smart home telehealth systems is a critical area for further exploration. The success of the system was largely dependent on the OA's support network, requiring strong offline relationships, and so the system may not be suitable for all OAs. Nevertheless, our study has shown that the system can be successfully applied to improve the experience of aging in place by OAs who have existing support networks, by transferring information and facilitating communication.

A final key finding from this study is that OAs and their SNs did not recognise the potential for such a system to assist aging in place, until they have had the opportunity to experience it. Processes need to be established such that OAs and their SNs can become familiar with smart home technologies and experiment with their use to become more accustomed to the possibilities that smart home technology could bring prior to any purchasing decisions. These systems need to be scalable to changing requirements, hence limiting choice to separate ecosystems without interoperability restricts the ability of such systems to meet these requirements, reducing potential health and wellness outcomes from smart home telehealth systems.

The study has some limitations. With the nature of qualitative research, the findings are not generalizable and so future research could investigate this topic with a wider scope. Participant recruitment was not drawn from a random sample of subjects, but it rather comprised individuals and organizations that actively volunteered to be involved in the study. The number of participants involved in the prototyping was limited and did not include the OAs' healthcare providers. The prototype demonstrated that smart home technologies can improve feelings of security, reduce loneliness and improve interpersonal communication but beyond that it did not explore specific health outcomes. Sensor systems lack quality clinical validation [15]. They must be tested and validated by health providers in real-life situations [26, 27]. Thus, it is recommenced that further studies on health outcomes are conducted.

5. Conclusion and lessons learnt

This study shows that it is possible to design and implement low cost, scalable smart home telehealth systems that meet OA end-user requirements, improve feelings of security, reduce loneliness and improve interpersonal communication. Key findings are that OAs need to be in control of their information, interoperability is central, and determining governance of information is critical. OAs, and indeed their support networks, need time to experience smart home technologies to determine how best to use such technologies to meet their changing needs.

The next steps of this study are to expand the functionality of the system by interfacing further devices; explore ways to extend the connectivity of the system to incorporate connections to healthcare providers; to develop information governance principles; and to undertake further real-life trials to gain a better understanding of the impact of the system on the OA, their support network members and potential health and wellness outcomes.

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Portable Health Clinic as a Telemedicine System with Appropriate Technologies for Unreached Communities

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Abstract. Poor healthcare infrastructure is the main barrier for providing quality healthcare services to rural communities in developing countries. Thus, these populations remain unreached, and there is a need to establish a method for ensuring the provision of appropriate and adequate healthcare services to these individuals. The portable health clinic (PHC) system has been developed as an effective telemedicine system to meet this objective. A trained village health worker can use this simple system for collecting vital information of the patient, upload the data to the online server, and connect village patients with a remote doctor to enable the provision of online consultancy using video conferencing. Although the PHC was initially developed to ensure primary healthcare service with a focus on non-communicable diseases, a major cause of death, gradually, tele-pathology, tele-eye care, maternal and child health care, and COVID-19 care modules have been added to provide special treatment in these areas as per local needs. The modular PHC system will continue to grow with the addition of novel features that aim to address the local needs. The low-cost and easy operation of the PHC system make it ideal for ensuring global health coverage in communities where inadequate medical facilities and poor-quality healthcare resources remain major issues.

Keywords. Telemedicine, primary healthcare, unreached communities, home delivery healthcare service, triage, patient engagement, population management

1. Introduction

Although healthcare service is a basic right of every human being, most individuals who live in rural areas of developing countries are deprived of this service. The main reason for this is the lack of adequate and appropriate healthcare facilities and resources, including doctors, nurses, and medical assistants. Several initiatives have been

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undertaken for improving the existing healthcare facilities worldwide [1-3]. However, for unreached communities of developing countries, there is a need for technically simple, usable, sustainable, and inexpensive healthcare service systems. The portable health clinic (PHC) system has been developed with this target in mind in Bangladesh under the joint collaboration of the Kyushu University of Japan and Grameen Communications of Bangladesh [4-5]. This system can serve as a model for developing countries because the resource availability and conditions in most such countries are similar to those in Bangladesh.

As shown in Figure 1 (left-hand image), the basic model of the PHC system includes the following four major components: (1) a set of medical sensors to be used for collecting patients' health data, (2) an online server system for data storage and sharing with remote doctors, (3) remote doctors for providing telemedicine service, and (4) a health worker (paramedics with 1-3 years diploma certificate) who collects the patients' health data and coordinate with remote doctors for tele-consultancy when required.

GramHealth: Portable Health Clinic
Global Communication Center
9F, Grameen Bank Bhaban, Mirpur - 2, Dhaka - 1216
Phone: 01974432584

Health Check-up Report and Prescription

Patient ID : 9999999999
Patient Name : [redacted]
Gender : Female
Age : 31 Years
Checkup Date : 29-01-2020
Health Status : ☐☐☐🟥

Height	162	cm
Weight	66	Kg
BMI	25.15	●
Waist	74	●
Hip	90	cm
Waist-Hip Ratio	0.82	●
Body Temperature	97.7	●
Oxygenation of Blood	99	●
Blood Pressure	130 / 90	●
Blood Glucose	17 (PBS)	●
Blood Hemoglobin	12.4	●
Urinary Glucose	±	●
Urinary Protein	-	●
Urinary pH		
Pulse Rate	66	●
Arrhythmia	Normal	●
Blood Cholesterol	157	●
Blood Uric Acid	5.2	●
HBsAg		

C/C:
» Low back pain » Blur vision » Diabetes

Rx

1) TAB. METFOXR 750 mg
1+0+1 After meal (30 Days)

2) TAB. GLIPITA M 500 mg
1+0+0 Before meal (30 Days)

3) CAP. EXIUM 20 mg
1+0+1 Before meal (30 Days)

Advice:
» Have a walk for 30 minutes regularly » Take a plenty of vegetables » If Blur vision please visit a doctor » To be sure whether you have Diabetes Mellitus. Have the following diagnostic test FBS (Fasting Blood Sugar). Please consult with a specialist if necessary »

Test:
» FBS (Fasting Blood Sugar) » HbA1c

Referred to:
» General Hospital

Dr. Nowshin Afroze Ranch (MBBS)
BMDC Reg. No: A-47225
Date: 29 Jan 2020
Cell: 01974-726115 (10AM-6PM)

Figure 1. The 'portable health clinic' system box and prescription

In the case of service delivery mechanism, the PHC system has adopted the philosophy that the clients are the most important factor that contributes to the sustainability of any business and the service provider should go to the client with the service as a sign of respect. Therefore, the PHC system has been designed to deliver healthcare service at the doorsteps of the rural community members to ensure easy accessibility of the service for the beneficiaries. So, the health clinic needs to go to the patients' homes instead of asking the patients to visit the clinic. Thus, the present novel system has been named 'the portable health clinic,' and the health worker provides home-based healthcare service to a patient by visiting the patient's home with the PHC system [6-8].

Before designing the content of this system, we studied the disease pattern in Bangladesh and found that 70% of the deaths in Bangladesh were attributable to non-communicable diseases (NCDs), such as hypertension and diabetes. Thus, the PHC system has been designed to provide primary healthcare with a special focus on NCDs. While delivering the service in the unreached rural communities, it was found that primary care is not enough and, in several cases, advanced patient care is necessary. Then, a new module of tele-pathology has been added to the PHC system as described below to support the remote doctor with further detailed patient reports. This additional feature has highly empowered remote doctors in the provision of secondary level of treatments via telemedicine. The remote doctors do need to refer the patients in some cases to the nearest district hospital when it is difficult to administer and support treatment via the tele-health system. This referral system forms a crucial part of the PHC system wherein only patients with serious conditions and specific needs are referred to sub-district or district hospitals that have limited resources. This enables the referral hospital to ensure optimal use of their limited healthcare resources for selected patients who need special care and prevents the unnecessary crowding by low-risk patients. The low-risk patients can be supported by the remote doctors by the PHC service.

The triage feature of the PHC system also plays a crucial role in reducing the workload of the remote doctors. The PHC triage classifies the patients in the following four categories based on their collected health data: (1) green or healthy, (2) yellow or suspicious, (3) orange or affected, and (4) red or emergent. The green and yellow patients are usually supported by the health workers who do not need any medication but receive advice-based preventive care. The remote doctors are consulted for the orange and red patients as well as some selected yellow patients. Thus, the limited human resources of the healthcare system are managed to ensure their optimal use. This is a very important factor for ensuring better healthcare services with the use of limited resources in unreached communities.

2. The PHC System Operation

The primary aim of the PHC system is to make primary healthcare services accessible to unreached rural communities. However, the care of patients with NCDs, such as hypertension and diabetes, was considered from the beginning. Thus, the PHC system box includes the following sensors (Table 1):

Table 1. Medical sensors and materials with measurement items in the PHC system

No.	Device Name	Measurement Items
1	Thermometer (Omron)	Body temperature
2	Digital BP Machine (Omron)	Blood pressure and arrhythmia
3	PulseOxi Meter	Pulse rate and oxygenation of the blood
4	EasyMate G-Hb	Blood glucose (random)
5	Manual Measurement Tape	Height
6	Weighing Machine	Weight
7	Digital Measurement Tape	Hip, waist, and hip/waist ratio
8	EasyMate G-Hb	Hemoglobin
9	EasyMate GCU	Uric acid
10	Uriesu –Tc (Terumo)	Urinary protein, urinary sugar, and urobilinogen
11	EasyMate GCU	Cholesterol
12	Blood Grouping Reagent	Blood group

This system box also includes an internet-enabled tablet personal computer, with PHC apps installed for storing health data to the online server. This is accessible to the remote doctor and enables video conferences between the patient and the remote doctor for tele-consultancy. Additionally, it includes a portable printer for printing prescriptions and giving them to the patients on the spot.

Generally, one health worker provides service in one rural community as an entrepreneur. The health worker visits each registered patient as per the schedule and provides home-based healthcare service. Figure 2 depicts the service process. First, the health worker interviews the patient to collect his/her medical history and then collects the necessary vital information using the PHC service box equipment (1). All data are then entered into the PHC apps, and the patient is classified as per the triage (3). If the patient is classified as green or yellow, the health worker uploads the data to the online server, provides a printed health report, and gives the necessary advice to the patient (7). However, if the patient has any complication that would require medication, or if the triage result is orange or red, the health worker uploads the data to the online server (4), immediately notifies the online doctor, provides the patient's registration identification number to enable data monitoring, and connects the patient to the doctor for a video consultation. Then, the remote doctor prepares a prescription and uploads it on the online server under the patient's profile (6). Finally, the health worker downloads the prescription, prints it, and shares it with the patient (7).

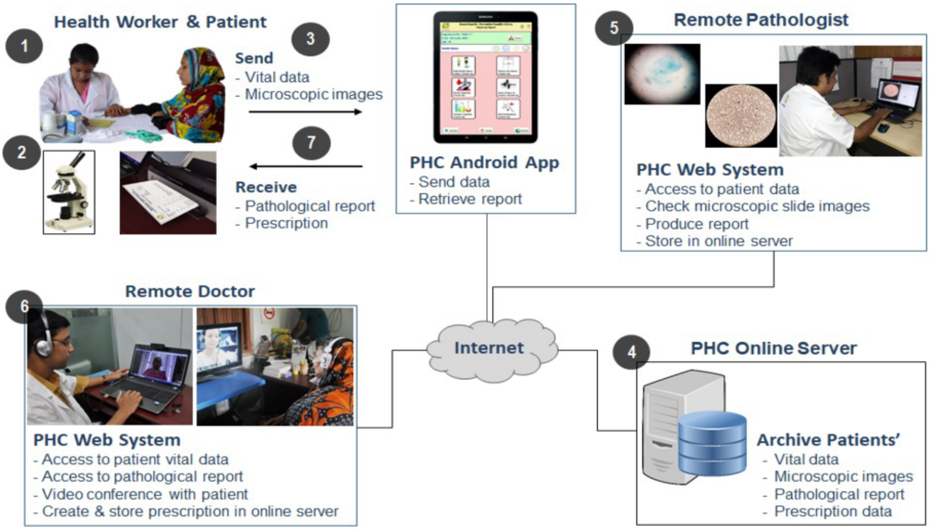

Figure 2. Operation model of the portable health clinic system

In cases where the remote doctor requires additional pathological reports for the patient, the trained tele-pathology staff (a trained rural laboratory technologist) collects a sample, prepares a physical report, and produces a sample slide with 6–10 microscopic images (2). These microscopic images are uploaded to the online server with the physical report via the PHC apps (3). Then, the remote pathologist prepares the pathological report investigating the microscopic images of the slide and the physical report from the laboratory technologist (5). This report is then uploaded to the online server (4). Finally, the remote doctor prepares the prescription with the reference of the pathological report.

The health worker prints the prescription and explains it to the patient before transferring for better understanding. The PHC prescription contains the basic health checkup report and details of the doctor's consultation [Figure 1, right-hand image]. All vital data are marked with color as per the triage result. This is crucial for rural patients because they do not understand the significance of the numerical data but can easily understand the severity of the status of each item via color coding of green, yellow, orange, and red. This encourages the patients to follow the advice of the doctors and/or health workers.

3. Personal Health Record (PHR)

Today, PHR is considered an important tool for healthcare services. This is more important in the case of tele-medication because the doctor cannot see the patient in person. The PHC system creates the PHR of every patient automatically. A patient can monitor his/her own health data with a graphical representation using PHC apps and be aware of their health status. If needed, they can contact the PHC staff with their feedback or complaints. Thus, this basic 'patient engagement' mechanism helps in building the awareness of the patient and contributes to improving healthcare service in the form of 'patient-reported outcome' [9-10].

For data interoperability, it is very important to maintain a standard PHR structure. Currently, there is no available international PHR standard. The PHR in the PHC system has been following the Japanese PHR standard although it does not maintain all 42 items at this stage [11]. Gradually, with the development of the PHC system, the remaining items will be added to the system.

4. Special Features

The rural communities of developing countries experience various diseases, similar to other populations. Thus, when the PHC program offers primary healthcare, sometimes people are dissatisfied because they also require the next level of treatment for their diseases. Therefore, the PHC system has added new modules with advanced features that would serve these higher needs of the community. So far the PHC system has added (1) an NCD module in the basic service, (2) a tele-pathology module, (3) a tele-eye care module, (4) a maternal and child health (MCH) care module, and (5) a COVID-19 care module [12].

4.1. Non-Communicable Disease

Seventy percent of all deaths in Bangladesh are attributable to NCDs. Thus, when the basic module was designed, a special focus was on two major NCDs, hypertension and diabetes [5]. Thus, the medical sensors for blood pressure measurement and glucometer have been added to the sensor sets. The PHC system has also adopted the triage concept of NCDs of Japan, with modifications as per the Bangladesh context.

4.2. Tele-Pathology Service

As a telemedicine service system, the PHC system offers service assisted by remote doctors. These doctors are unable to see the patients in person; therefore, they need to obtain as much patient information as possible. The PHC system box contains limited sensors for measuring only the basic vital information. In many cases, remote doctors require some pathological data. Unfortunately, there is a considerable shortage of pathologists and pathological laboratories in rural Bangladesh. However, there are many rural pathology laboratories operated by laboratory technologists with 3 year Diplomas in pathology. The tele-pathology module of the PHC has empowered these laboratory technologists (local pathologists) by connecting them with urban pathologists. Here, the trained laboratory technologists of the PHC system collect the sample, prepare a physical report, and share the microscopic images of the glass slides of the sample with the urban pathologist [13]. Finally, the pathologist prepares the final pathology report that is used by the remote doctor for their consultancy.

The current tele-pathology service of the PHC system supports the preparation of various reports including (i) hematological report, (ii) biochemistry report, (iii) microbiology report, and (iv) routine examination report of urine, sputum, and stool.

4.3. Tele-Eye Care Service

Patients in rural areas of developing countries, such as Bangladesh, are at a high risk of ophthalmic diseases. By contrast, there are only 1,000 ophthalmologists for a population of 160,000,000, resulting in only 0.063 doctors per 10,000 people. Thus, there is a huge need for ophthalmic support with the PHC system in rural communities. To address this issue, the PHC system has added the tele-eye care module that works on a mechanism similar to that used for the tele-pathology feature [6]. Here, the local trained health worker collects patient data, including retinal images using a digital fundus camera that are shared with the remote ophthalmologist. Finally, the ophthalmologist prepares the report after a video conference with the patients. Presently, the PHC tele-eye care system offers services including; (i) primary investigation, (ii) vision test, (iii) final examination, (iv) refraction, (v) glass prescription, and (vi) eye prescription.

The PHC tele-eye care module aims to adopt the new artificial intelligence-based automated detection algorithm to automatically identify diabetic retinopathy. This technical assistance is expected to contribute considerably toward reducing the workload of local health workers and remote ophthalmologists.

4.4. Maternal and Child Health Care Service

There is an urgent need for a home-based delivery service of MCH care in rural areas because, in many cases, village women have some cultural and religious reservations about visiting distant city hospitals. Furthermore, in most cases, pregnant women from rural areas prefer to consult a female doctor in person. Thus, the MCH care module has been added to provide better healthcare services to rural women and newborn babies [14]. Therefore, a PHC service box has added a handy fetal Doppler machine for checking the baby's heartbeat and a digital ultrasonography machine for monitoring the baby's position in the mother's womb. It follows the guidelines of the World Health Organization (WHO) for monitoring the health of pregnant women and newborns from the beginning of their pregnancy up to six weeks after childbirth [15]. A total of eight checkups are performed during this period by the PHC rural health workers followed by tele-consultancy by a gynecologist in the city.

Additionally, the MCH service supports village women, especially all women in the reproductive age group (15–49 years) and performs basic health checkups using PHC as preventive healthcare services.

4.5. COVID-19 Care Service

This is the most recently added module to the PHC system. During the COVID-19 pandemic in 2020. This system has a triage function to accurately classify the suspected patients who are recommended for a PCR test [16]. This is believed to lower the testing cost and workload on the test center with limited resources while ensuring that the patients who require a test are subjected to the appropriate examination.

Based on the test results, the system classifies the subjects into the following five categories: green, light yellow, yellow, orange, and red. Green indicates that the patient is healthy and safe from COVID-19 infection. Light yellow means that the patient is slightly likely to have an infection and should maintain home quarantine with self-monitoring. Yellow shows that the patient is considered probable to have an infection and should maintain home quarantine under the supervision of a PHC health worker. Orange shows that the patient is suspected to have a COVID-19 infection and should immediately talk to a PHC call-center doctor and undergo a PCR test if advised. Otherwise, the patient should maintain home quarantine under the supervision of a PHC health worker. Red means that the patient is very likely to be infected and should undergo a PCR test or visit a COVID-19 care hospital immediately for further follow-up.

The PHC for COVID-19 system can also be used for the remote (or social distancing-based) treatment and follow-up of patients who are home quarantined for suspected or mild-positive COVID-19 infection. The COVID-19 system box contains four items of self-checking medical equipment; one thermometer, one pulse oximeter, one BP machine, and one glucometer. This COVID-19 system and tablet PC allows for the patient's health monitoring, and communication between the patient and doctor for tele-consultancy, while maintaining social distance. This ensures the safety of both the patients and the health professionals, which is crucial for highly infectious diseases, such as COVID-19. This system box can be rented by an individual COVID-19 positive patient or shared by several patients in a community with the support of the local health worker. This system can be easily operated by an individual patient with the aid of the operational manual after a short operational training.

5. PHC Service Statistics in Bangladesh

The PHC system started basic healthcare service in 2010. Since then, about 44,500 patients have been managed by approximately 40 PHC systems boxes across 18 districts of Bangladesh until November 30, 2020. For these services, 4,500 pathology reports have been provided by the tele-pathology service for 1,900 patients as recommended by doctors.

The tele-eye care service was started in late 2017 in three districts of Bangladesh and have treated approximately 3,000 patients. The MCH care service was started in 2019 as a pilot program in a district of Bangladesh and has served around 800 women and babies, including 110 pregnant women. As a continuum care of MCH, this service will be continued for all pregnant women, new mothers and babies until 2 years after childbirth.

PHC for the COVID-19 care module was added in June 2020 during the COVID-19 pandemic. As of writing this report, this system had provided care to approximately 1,100 people in three districts of Bangladesh for the identification of suspected COVID-19 and provided support for home quarantined probable/suspected COVID-19 patients.

This is expected to exert a considerable positive impact in terms of reduced workload on the PCR test centers and availability of the test for individuals who really need these services.

This project conducted several surveys to obtain patient feedback. Mostly the village women liked this service because they could receive healthcare services in their home. Although the village people can get primary care service from the public hospital free of cost, they prefer the PHC service because they can avail the service maintaining privacy with an affordable price and avoid long distance travel for visiting nearest public hospitals in the sub-districts. Also, the village women are comfortable with the PHC service because most of the health workers are women and they feel easy to discuss their problems with them.

6. Discussion

6.1. Target Patients

The PHC system is not only a tele-health system for treating current patients but also a tool for community-based healthcare in the population-management approach. In addition to providing telemedicine services to the orange and red category patients who need immediate medication, the PHC system can provide preventive care to those characterized into the green and yellow categories. As per this concept, developing countries can skip the very long and expensive process of medical service development that has been observed in the past, and achieve modern medical services at a low-cost.

Although the PHC system has been developed for the rural communities that do not have access to adequate and appropriate healthcare, it is suitable and very useful as a home-based healthcare delivery service for elderly patients in urban areas. Most elderly patients have NCDs and need regular checkups and follow-ups. The PHC service could help them avoid regular hospital visits and provide the required healthcare support at home at a pre-scheduled, convenient time. Thus, they can avoid the physical stress involved in traveling to the hospitals and waiting in the long service queues. So far, the urban model of the PHC system in Bangladesh has provided services to 36 apartments in six different areas of Dhaka city covering 1,717 elderly patients. The issue of elderly patients is more prominent in developed countries. Recently, the demand for telemedicine-based healthcare service delivery is increasing, and many developed countries are showing their interest in PHC-type services for their elderly citizens.

6.2. Technical Challenges

The PHC system needs to use a number of small, lightweight and low-cost medical sensors for its usability and sustainability. However, only few such high-quality sensors are commercially available. The rest are collected from the available items in the local market. Although the PHC research team evaluates the products from different manufacturers and selects the best possible for the PHC system, there remains a concern of data accuracy. Moreover, there is a need for additional sensors to respond to patients' needs; however, these are not available. The PHC system aims to offer services at a low-cost; therefore, we expect manufacturers to design new, low-cost and portable devices in the future.

One of the main issues of the tele-health system is that of errors made during data entry and measurement [17-18]. A wrong entry may lead to an inaccurate diagnosis and disallow accurate consultation and treatment by the remote doctor. Better training on system operation of health workers can reduce this error but cannot ensure 100% accuracy. Alternatively, an RFID-based wireless system can be used to directly transfer the measured data to the system. Unfortunately, all the commonly available sensors that can be used in the PHC system are not RFID-enabled, and such RFID-enabled devices are too expensive for the low-cost PHC service. The use of more low-cost, RFID-enabled devices would considerably enhance the PHC system and ensure good quality healthcare service.

As of writing this report, the PHC system is working to adopt a software solution to predict an acceptance range by analyzing previous records, called the personal acceptance range [6,19]. If the data cross the acceptance ranges, the system will automatically give a warning, and the health worker will double-check the data to remove any error that may be present. If the patient has insufficient previous data, the system predicts data from subjects of similar age and sex; this is called the group acceptance range. Besides, there is a hypothetical range as a preset of all ages and sex which is called human acceptance range. Once this model is implemented, the PHC system will be able to significantly avoid manual data entry errors and errors attributable to the malfunctioning of medical sensors.

6.3. Social Impacts

The PHC service has various social impacts to the service areas. It not only improves the access to good healthcare for rural communities but also engages rural unemployed youths as health workers in the service. Most of the target patients in the rural communities are women who do not have many opportunities to visit distant healthcare facilities; therefore, female health workers are primarily engaged in this home delivery service to ensure the comfort and privacy of female patients. This creates jobs for the rural female population who can find employment in their home village. Thus, as shown in Table 2, the PHC service directly or indirectly contributes to fulfilling various Sustainable Development Goals (SDGs) set by the United Nations [20].

Table 2. PHCs contribution to sustainable development goals

No.	Objective	How does it relate
SDG 1	No poverty	Establishes businesses and employment
SGD 2	Zero hunger	Creating employment opportunity for the poor
SDG 3	Good health and well-being	Population and individual health management
SDG 5	Gender equality	Creating business opportunities for females
SDG 8	Decent work and economic growth	Establishes a business model
SDG 9	Industry, innovation, and infrastructure	Establishes a collaborative platform where the device vendors, software solution providers, and researchers can find their incentives
SDG 13	Climate action	Establishes a post-disaster service
SDG 17	Partnerships for the goals	Creates partnerships between Japan and Bangladesh and other countries

6.4. Geographical Expansion

As a technologically simple system, the PHC service can be easily replicated and used in any low-resource community. It can be a useful tool for ensuring universal health coverage (UHC) by providing sustainable, doorstep healthcare services in unreached communities of developing countries at an affordable cost. The PHC system has already been implemented in some parts of Cambodia, India, Thailand, and Pakistan with the support of local partners. As of writing this report, this system is being implemented in some other countries and is soon expected to be used in China, Indonesia, and Malaysia.

7. Conclusions

The PHC is a modular tele-health system where new modules, such as tele-pathology, tele-eye care, tele-MCH care, and COVID-19 care, have been added over time as per the local needs of the community. With the constant emergence of new requirements, the PHC system will continue to develop new modules and enhance with time, ultimately evolving into a comprehensive tele-health solution.

Given the easy-to-use operation model and portability of the PHC system, it is considered to be an extremely useful tool for use in support shelters during natural disasters and emergencies. Thus, the PHC system aims to adopt a new triage logic for disaster management and support in emergency situations [21].

As discussed above, some technical issues should be addressed. In addition, the PHC system aims to apply the use of artificial intelligence technology for improving the service and lowering the cost. The achievement of these objectives shall be the direction for the next generation of the PHC system.

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Development of a Conceptual Framework for e-Health Readiness Assessment in the Context of Developing Countries

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Abstract. Background: e-Health readiness has been described as the preparedness of healthcare institutions, communities, or individuals for the anticipated change brought by programmes related to ICT use. Assessment of e-health readiness prior to the implementation of e-health innovations can therefore facilitate the process of change for individuals and organisations to adopt e-health programmes and avoid disappointment. The literature shows that although many e-health readiness assessment frameworks and tools exist, none meet all the requirements for e-health readiness assessment in developing countries. The aim of this study was to develop an e-health readiness assessment framework applicable to developing countries. **Methods:** A three-step process gleaned from the e-health literature (literature review / material collection; analysis / content analysis; consolidation / conceptual framework synthesis), together with iterative and reflective processes based on prior research undertaken by this group, guided framework conceptualisation and design. **Results:** An evidence-based framework was developed that: incorporates the need to assess readiness for each e-health component separately; identifies government's central role in engaging all relevant stakeholders; and the need to assess the adequacy of a country's infrastructure and infostructure prior to e-health planning and possible implementation. Also addressed by the framework is a need for an e-health readiness assessment to be undertaken using separate tools for technical and non-technical individuals. A country's e-Readiness is highlighted as an important indicator for e-health readiness. **Conclusions:** The intent of the final framework is to inform and assist policy and decision makers, and facilitate future successful implementation of e-health initiatives in the developing world.

Keywords. e-Health, readiness assessment, frameworks, models, developing countries

1. Introduction

e-Health has been defined as the use of information and communication technologies (ICT) in support of health and health related fields, including healthcare services; health surveillance; health literature; health education, knowledge and research [1]. e-health has

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been an area of priority for the World Health Organization since 2005 and has been suggested to comprise of four elements: e-commerce (business), e-learning (training – awareness, teaching, instruction, and education), health informatics (data gathering, storage, analysis, and distribution), and telehealth, including telemedicine (either interactive real-time or store and forward activity) [2].

Implementation of e-health innovations continues to grow and mature in both the developed and developing world [2-4]. Developing countries face health challenges that could be ameliorated by e-health implementation, including a shortage of healthcare resources [5] and challenges with healthcare quality, accessibility and affordability [6]. Despite benefits associated with e-health, implementation failures unrelated to the e-health technology used have also been reported [2, 7]. A majority of these failures might actually be related to a lack of e-health readiness.

e-Health readiness has been described as the preparedness of healthcare institutions, communities, or individuals for the anticipated change brought by programmes related to ICT use [8]. Assessment of e-health readiness prior to implementation of e-health innovations can therefore facilitate the process of change for individuals and organisations to adopt e-health programmes and avoid disappointment [9]. e-Health readiness assessment has been considered crucial to the successful adoption and sustainability of e-health implementations for the last two decades [10-12]. Indeed, the importance of readiness has been documented and described in various developing country settings and for various uses as both key to successful e-health implementation and as a factor in failed implementations [11-15]. It can be assumed that successful implementation of e-health cannot be achieved without the readiness of the broad spectrum of stakeholders and users (providers, patients, public, politicians, public servants, managers and industry). A recent study noted that even though many e-health readiness assessment frameworks (eHRAFs) exist in the literature, none was entirely suitable for assessing e-health readiness in the context of developing countries [7]. Limitations included: some of the frameworks assumed an adequate pre-existing ICT infrastructure, awareness of planned e-health interventions by respondents, the presence of available Internet connectivity, a healthcare sector with established e-health services, or the presence of sustained government will and support, and finally no framework assessed Internet awareness or all eight common readiness areas [7,8,16]. Given the ubiquity and importance of e-health for developing countries, a suitable eHRAF relevant to their needs is required.

This study is founded on a structured review of the literature on existing e-health readiness assessment frameworks and interviews with local in-country experts already conducted by this group. The structured review evaluated suitability of existing e-health readiness assessment frameworks for use in developing countries [7]. Eight e-health readiness assessment types were identified and defined, organisational readiness, technological-infrastructural readiness, government readiness, societal readiness, healthcare provider readiness, engagement readiness, core readiness and public-patient readiness (Table 1). The frameworks identified varied in underlying assumptions and perspectives, lacked any unifying theory, and often failed to address government readiness, societal readiness, and cultural readiness, and highlighted the need for separate assessment of each e-health component and user segment [7]. Interviews with purposively selected relevant experts in Botswana elucidated additional factors to be considered when assessing e-health readiness in the context of developing countries. Thematic analysis of the interviews identified four major e-health readiness themes: stakeholder issues, resources, access, and governance (national and institutional) [17].

Building upon prior research, this study designs and creates a conceptual framework for a developing country-specific e-health readiness assessment. A conceptual framework is a diagram that summarises a complex setting or system in a way that researchers believe can best illustrate key evidence-based factors and explain relationships between these factors. The goal is to facilitate an understanding of a complex setting in a simplified and accessible fashion.

The aim of this paper is to describe development of an eHRAF that will inform policy- and decision-makers and facilitate future successful implementation of e-health initiatives in the developing world.

Table 1. Definitions of e-Health readiness assessment types obtained from literature review [7].

e-Health readiness assessment type	**Definition**
Organizational readiness	Gauges the extent to which the institutional setting and culture supports and promotes awareness, implementation, and use of e-health innovations (e.g., presence of relevant policies; senior management support).
Technological/Infrastructural readiness	Gauges the availability and affordability of ICT resources necessary to implement a proposed e-health innovation (e.g., skilled human resources, ICT support, quality ICT infrastructure, and power supply.
Healthcare provider readiness	Gauges the influence of a healthcare provider's personal experience; primarily their perception and receptiveness towards the use of e-health technology.
Engagement readiness	Gauges the extent to which members of a community are exposed to the concept of e-health and are actively debating its perceived benefits as well as negative impacts. It also involves gauging the willingness of members of a community to accept training on e-health.
Societal readiness	Gauges the degree of 'interaction' associated with a healthcare institution. Interaction is described by three parameters; interaction among members of a healthcare institution, interaction of a healthcare institution with other healthcare institutions, and interaction of a healthcare institution with its local communities.
Core readiness	Gauges the extent to which members of a community are dissatisfied with the current status of their healthcare service provision, see e-health as a solution, and express their need and preparedness for e-health services.
Government readiness	Gauges the extent to which a country's Government and politicians support and promote awareness, implementation, and use of e-health innovations (e.g., presence of relevant policies, and funding).
Public/Patient readiness	Gauges the extent to which members of the public and patients are aware of, and can afford and access, e-health services. It also involves gauging the influence of their personal experiences on their perception and receptiveness towards the use of e-health technology.

2. Methods

Although 'conceptual frameworks' can readily be found in the literature, there is very little specific guidance for a process by which to design and develop a conceptual framework for application to e-health. Some fundamental steps were identified from the literature. These were: 'literature review, analysis, and consolidation' [18], or 'material collection, content analysis, and conceptual framework synthesis' [19]. In the absence of a standardised method for conceptual framework development, a similar three step approach was used, namely: 'literature review / material collection', 'analysis / content analysis', and 'consolidation / conceptual framework synthesis'.

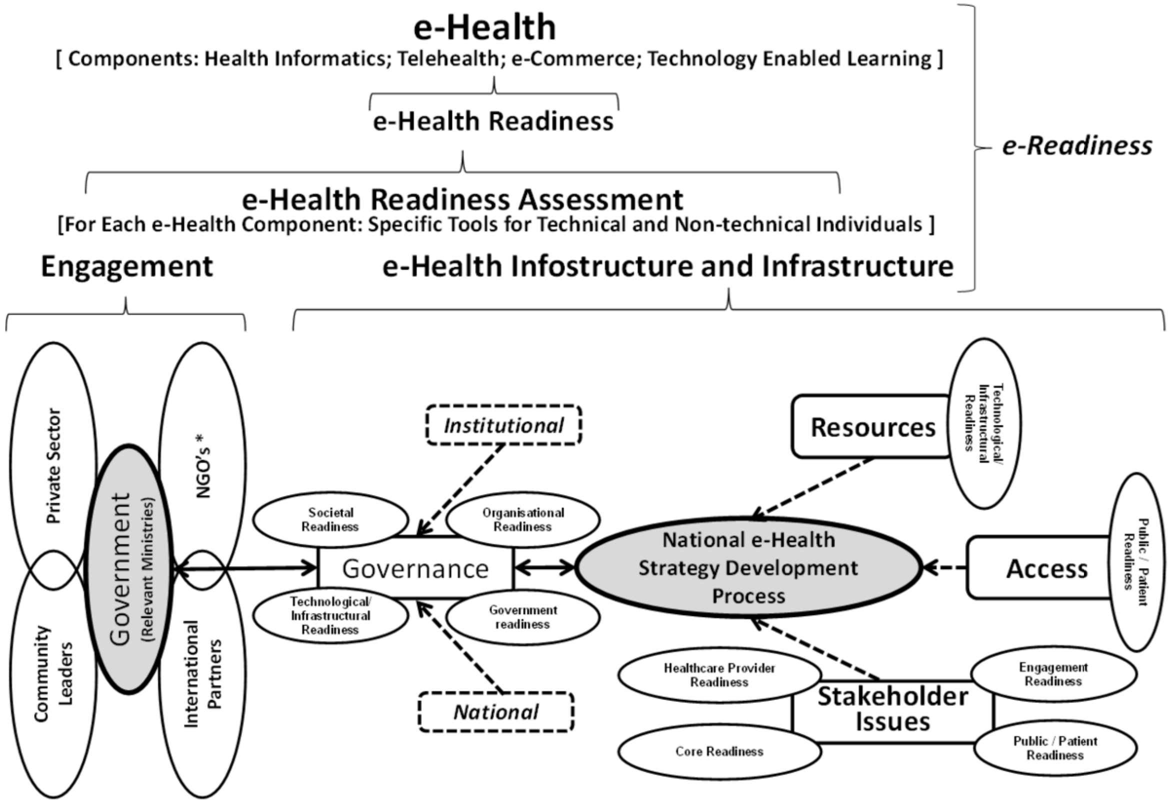
To ensure development of an evidence-based conceptual framework, the findings from two prior studies (a literature review [7], and consultation process with e-health experts in Botswana [17]) were used as the evidence-base. Together, these studies satisfied the first two steps of the approach: literature review / material collection, followed by analysis / content analysis.

Thereafter a 'consolidation / conceptual framework synthesis' step was undertaken. The initial consolidation process involved the authors identifying all key elements relevant to and essential for inclusion in an eHRAF for developing countries. Identification of these key elements was guided by prior work which had 1) provided agreed definitions of terms relating to e-health readiness, and 2) grouped various aspects or facets that impact e-health readiness into distinct dimensions [7, 17]. Using an inductive iterative approach, this collective knowledge was conceptualised and processed into preliminary designs to build a framework that illustrated relationships between the identified key elements and their role in determining e-health readiness.

The inductive, iterative and reflective processes guiding framework design ceased when the underlying principles of the framework appeared plausible, and the framework was considered sufficiently robust that it could be used to guide e-health implementation through understanding how to effect change and bring about improved e-health readiness. Thereafter, the proposed framework was assessed by the authors to determine if it 'fitted' the desired purpose. This assessment involved the authors reflecting on their previous work, as well as their experience of past settings as cases, and gauging if the framework was practical and understandable, and revising it by removing or adding any element considered redundant or missing.

3. Results

The proposed e-health readiness assessment framework (eHRAF) for developing countries is presented in Figure 1. The framework first illustrates the overarching role of e-readiness of a setting which will inevitably impact e-health readiness. The framework then highlights separate and distinct assessment of e-health readiness for each component of e-health (health informatics, telehealth, e-commerce, and technology enabled learning), and the need for separate e-health readiness assessment tools for each component and for technical and non-technical individuals (e.g., ICT staff versus clinicians and managers). Two aspects are then identified as essential factors in determining an e-health ready setting, both of which require specific assessment at different points in time. First, the presence of stakeholder engagement, ideally addressed early in the process, i.e., from inception.



* Includes Humanitarian and Faith-Based Organisations

Figure 1. e-Health readiness assessment framework (eHRAF) for developing countries.

Second, the presence of relevant e-health infostructure and infrastructure, ideally addressed later in the process once specific e-health solutions have been identified.

Within the framework, government is at the core of stakeholder engagement (Figure 1). Illustrated categories of relevant and essential stakeholders to be engaged are: the private sector, community leaders, international partners, as well as non-governmental organisations (NGOs), humanitarian organisations, and faith-based groups. The need for development of a comprehensive and informed national e-health strategy as a prerequisite to e-health readiness is shown.

4. Discussion

While developed specifically for application in the context of developing countries, the proposed conceptual framework also attempts to unify those existing e-health readiness assessment frameworks gathered from a prior literature review. The framework presented in this paper provides insight regarding how multiple factors interact to influence the e-health readiness of a given setting, and how this knowledge helps identify specific actions and interventions that help lead to successful e-health implementation, in the developing country context. Each country will need to fine tune the framework when applying it, based on local circumstances.

Shuvo et al. identified a number of important issues relevant to implementation, as well as scale-up and sustainability, for e-health initiatives in low- and middle-income countries [20]. These issues, although termed slightly differently, were also identified within the framework presented here. However, the framework presented here is more comprehensive (addressing all eight common readiness areas, [7]), and deals with an expanded content at a higher level and in a more programmatic fashion.

Emphasised in the current framework is the use of stakeholder specific assessment tools to avoid challenges, like those experienced in a previous study in a different developing world setting where a generic e-health readiness assessment tool was used. Study participants failed to respond to some questions because they were unfamiliar with specific matters raised, or because they felt they did not have the (political) authority to answer the questions [16]. This illustrates that the use of a single generic tool for e-health readiness assessment within any framework has the potential to negatively affect the validity of such an assessment. Indeed, the same sentiment was expressed by Khoja et al. who in their study developed separate e-health readiness assessment tools for managers and healthcare providers, so that e-health readiness could be determined from both perspectives [8].

e-Health consists of various components including health informatics, telehealth, e-commerce, as well as technology enabled learning [2]. As previously discussed, to assess e-health readiness comprehensively the various components must all be taken into consideration [7]. Furthermore, readiness for one component does not necessarily translate to an overall e-health readiness, or readiness for any other specific component.

e-Readiness, of which e-health readiness is just one aspect, has been defined as a measure of the quality of a country's ICT infrastructure and the ability of its consumers, businesses and governments to use ICT to their benefit [21]. When assessing e-readiness for Estonia, the PRAXIS Centre for Policy Studies used the following indicators: network access, networked society, networked education, and networked economy [22]. As such, the degree of e-readiness of a country has a direct influence on its e-health readiness.

In developing countries e-health is largely funded, directly or indirectly, by external donors and government, as opposed to private enterprise, which is somewhat different to many developed countries. Thus, foreign NGOs, faith-based groups, and multinational institutions have been involved in the funding of e-health projects in many developing countries, including India, Uganda, Rwanda, Zambia, Ethiopia and Tanzania [23, 24]. The role of the private sector in the development of better health systems and the improvement of healthcare has also been documented, creating a need for the private sector to be more engaged in the process of focussed and 'evidence-based health need' e-health implementation [2]. Medical aid providers, mobile network operators, the TelCom industry in general, technology developers, the financial industry, as well as private healthcare providers, are some of the private sector candidates whose engagement can result in provision of e-health friendly solutions, thus contributing to e-health readiness.

The framework also illustrates the central role that government needs to play in ensuring e-health readiness [25]. This involves engaging all relevant stakeholders, including potential funders. Barkman and Weinehall [26] have emphasised the need for such a central role to be played by the government, noting that political responsibility lies in creating optimal conditions for m-health implementation, in terms of both infrastructure and regulatory framework. Beebeejaun and Chittoo [27] have documented the important role of government policies in maximizing the probability of success in implementing information systems. Similarly, Bloom et al. emphasised the importance of government to protect the interests of the 'poor and politically weak' and to 'engage actively in the innovation process' as a new health knowledge economy was shaped [28]. A study by Abel and Obeten [23], concluded that lack of political will was one of the reasons why foreign NGOs and multinational institutions were not as eager to fund e-health projects in Nigeria as they did in other developing countries. A report on assessment of e-health projects and initiatives in Africa noted that e-health projects funded by external donor agencies ceased when the donor funding was exhausted [29]. As such in ensuring sustainable implementation of e-health projects and hence e-health readiness, a government need not depend on external funding alone for its e-health projects but also on itself. Insufficient government funding in adopting e-health solutions has been documented as one of the contributing factors to failed implementations [30].

The importance of stakeholder engagement when implementing e-health initiatives has been appreciated for some time [31-33]. It is generally considered a change management issue and to entail communication approaches to provide rational business reasons and to manage the less rational emotional reactions to the change [34]. Of primary importance, although seldom achieved, is the engagement of all relevant stakeholders at the outset of e-health implementation, which results in coordinated efforts and promotes awareness and e-health readiness through stakeholder buy-in.

In most communities in developing countries, especially in Africa, there exists a social structure headed by community leaders who could be chiefs or councillors. Involvement of such community leaders during the engagement process ensures that any public concerns and expectations with regards to e-health are considered hence promoting engagement readiness, public/patient readiness, core readiness and - to some extent - healthcare provider readiness and societal readiness [7].

The framework also illustrates that the efforts from such engagements need to inform the process of national e-health strategy development. A national e-health strategy, and its development process, is core to e-health readiness as it provides guidance for implementation. This guidance includes recognition of relevant infrastructure as well as providing a conducive e-health infostructure. Infostructure, a term used in many disciplines [35] is inconsistently defined, and must be differentiated from the accepted term infrastructure (e.g., transportation, power supplies). Adapting the work of Latif et al. [35] in the realm of e-health, infostructure can be considered the soft elements that support infrastructure, and includes elements of human resources, organisational and administrative structures, policies, regulations and incentives.

The importance of a national e-health strategy in strengthening e-health implementation is also emphasised in the national e-health strategy toolkit of the World Health Organization (WHO) and International Telecommunication Union as well as by other authors [33, 36, 37]. Indeed, strategy has been stated to be the driving force that places countries in charge of their own e-health destiny [34]. Thematic analysis of expert interviews (Table 2) highlighted the four themes of governance, resources, access, and stakeholder issues as areas necessary to be considered during development of a national e-health strategy and towards achieving e-health readiness.

The framework's primary strength is that it has been intentionally designed to address the needs of developing countries. It is also more comprehensive than other published frameworks which only directly address, at most, four of the eight readiness areas identified in prior research [7]. In addition, the study is evidence-based being formulated from the literature and expert opinion. A potential weakness is the restriction of experts to one country, since experts from differing countries may have differing opinions about the relevance or emphasis of constructs. The effectiveness and value of the current framework must be empirically demonstrated.

Table 2. e-Health readiness themes and subthemes from expert interviews [17]

Governance	Stakeholder issues	Resources	Access
National Governance • Political will • Legal framework • Implementation plan • Public private partnerships • e-Governance - e-health leverage • Healthcare service delivery - unique patient identifier - population distribution - health facility distribution • Power supply *Institutional* Governance • Policies • Regulations • Interoperability • Data stewardship • Security for e-health resources	• Engagement • Public awareness • Readiness • Change management	• Budget • ICT infrastructure • ICT infostructure - electronic health records • Human resources - human health resources - human e-health resources	• Literacy - technical literacy • Training - curriculum • Network reach • Internet availability • Affordability of access to e-media • Ubiquity to access e-services • Access to e-devices • Presence to access electronic health records • Availability of e-health resources in local languages • Rate of social media usage • e-health support

5. Conclusion

The e-health readiness assessment framework (eHRAF) presented is evidence-based, being developed using inputs gained from prior developing country research. This includes a structured review of the literature, a critical analysis of existing eHRAFs, and expert opinion regarding essential readiness themes. These inputs were then used to create and assess a new framework that identifies essential dimensions of readiness and how their relationships and points of intersection can be used to influence readiness-related activities and interventions. The output is a framework whose understanding, and use will inform policy- and decision-makers, and facilitate future successful implementation of e-health initiatives in the developing world.

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Asynchronous Teleconsultations: The US Military Experience in the Pacific

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Abstract. Tripler Army Medical Center (TAMC), located in Honolulu, Hawaii, serves as the US military's tertiary medical referral center for the Western Pacific. Over 20 years ago, the TAMC Department of Pediatrics developed an asynchronous provider-to-provider teleconsultation pilot program, eventually named the Pacific Asynchronous TeleHealth (PATH) system. A secure teleconsultation platform for pediatric sub-specialty provider-to-provider advice, the platform grew based on the needs of users, eventually expanding to serve all age-groups, with over 60 different specialties based at TAMC providing teleconsultation. Eventually, the success of PATH drove further expansion to serve military clinicians located in other overseas locations beyond the Asia-Pacific. This cost-effective model can be applied to civilian healthcare settings, particularly where geographic distance or limited connectivity are challenges to delivery of synchronous telehealth or in-person specialty care.

Keywords. Asynchronous, teleconsultation, store-and-forward, military, Pacific Region

1. Introduction

The US Department of Defense (DoD) Military Health System provides medical care to military Service Members and their family members around the globe. Tripler Army Medical Center (TAMC), located in Hawaii, is the tertiary medical referral center serving the DoD beneficiaries throughout the Western Pacific Region. This footprint includes more than 20 military clinics and small hospitals on installations located in Guam, South Korea, and Japan (Figure 1). The wide geographic span of this region across large bodies of water is also the only military region that spans the International Date Line, and involves 5 different time zones. Routine, in-person evaluation by a subspecialist located at TAMC involves air travel and several nights of lodging, making the utilization of telemedicine a more cost-effective tool for routine ambulatory subspecialty evaluations.

Coordination of synchronous telemedicine visits between TAMC and facilities located in Japan, Guam, and South Korea can be very challenging and disruptive to the

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daily workflow of the distant site provider. Provider-to-provider synchronous discussions regarding routine medical questions about a patient can also be an interruption to daily work for both the requesting primary care clinician and the subspecialist. Alignment of schedules, challenging and/or complicated processes for coordination of appointments, requirements for video equipment and a secure platform, and the bandwidth requirements for a synchronous video encounter are all barriers to gaining buy-in from healthcare providers and from patients.

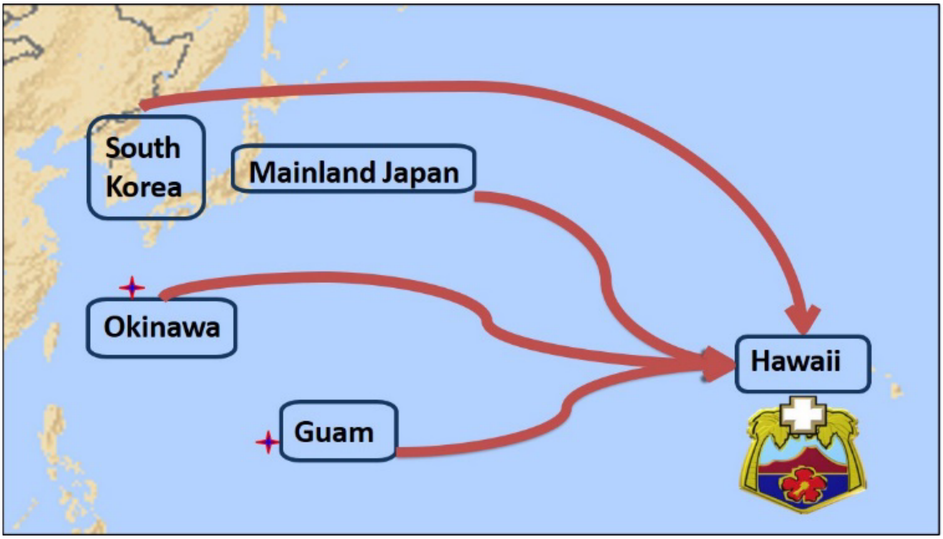

Figure 1. A map of the footprint where TAMC and PATH provide teleconsultation support. The locations highlighted above include military hospitals and clinics where >95% of referrals originate. Additional referrals come from locations throughout the Asia-Pacific in locations where Active Duty military and their family members are stationed, such as Australia, Singapore, and Thailand.

2. The Electronic Children's Hospital of the Pacific (ECHO-Pac)

In search of a way to provide subspecialty support to primary care clinicians stationed in the Western Pacific Region, the TAMC Department of Pediatrics received funding to establish a demonstration project utilizing a secure, asynchronous (store-and-forward), web-based platform for provider-to-provider pediatric specialty teleconsultation [1]. Initially called the Electronic Children's Hospital of the Pacific (ECHO-Pac), a web-based platform was built that would be compliant with the Health Insurance Portability and Accountability (HIPAA) Act and security requirements of a web-based healthcare platform. ECHO-Pac was initially used to provide support by pediatric pulmonologists at TAMC to 7 children with moderate to severe asthma (mean age 11.9 +/- 3.7 years) who were military dependents and living overseas in the Pacific Region [2]. It served as a way to augment the care they received from their general pediatrician or other primary care manager. Video recordings of the patient using their metered-dose inhaler (MDI) were submitted to the pediatric pulmonologist at specified intervals, and reviewed regarding their technique. In this demonstration project, children with asthma followed by teleconsultation for 1 year had fewer emergency room visits for asthma (3.85 +/- 5.14, range 0-15 vs. 0 visits, $p < 0.05$) and fewer unscheduled acute clinic visits (1.57 +/- 1.27, range 0-4 vs. 0.286 +/- 0.48, $p < 0.05$) in the study year versus the preceding year. There were two hospitalizations in the year prior to the study; however, no patients were hospitalized during the study.

2.1. Evaluation of Asynchronous Teleconsultation on Care and Cost Avoidance

Building upon the initial success with pediatric pulmonology and asthma consults, the Department of Pediatrics expanded the specialties available in ECHO-Pac, and the utilization of the system was systematically studied for a year to further characterize its use, impact on access to specialty care, and whether it prevented travel to Hawaii for routine outpatient specialty evaluation [1]. This study model added the role of consult managers at hub location, added in email notification to spoke and hub providers when new comments were added to a case (devoid of any patient-identifying information), and included the use of electronic backfill so that if a specialty provider at TAMC was away on extended leave, or was deployed and therefore unable to reply to teleconsultations, a pediatric specialist located at a different DoD tertiary care center was invited to reply to clinical teleconsultations to avoid underlap in coverage. Data was collected between 2002 and 2003, and included a total of 267 cases from 16 spoke locations in the Asia-Pacific. A panel of 5 pediatric physicians who were not involved with the teleconsultations independently reviewed each case using a Likert scale to answer the following questions:

- Was the diagnosis changed or modified by the consultation?
- Was the diagnostic plan changed or modified by the consultation?
- Was the treatment plan changed or modified by the consultation?

Cost savings was evaluated by the physician review panel based on responses to the following question:

- If telemedicine were unavailable, would this patient have been evacuated on a routine flight to the medical center for consultation and care?

The diagnosis was changed or modified following the use of a teleconsultation in ECHO-Pac in 15% of cases, the diagnostic plan for evaluation changed in 21% of cases, and the treatment plan was changed or modified in 24% of cases ($p < 0.01$). In addition, the review panel identified avoided patient movement in 12% of the cases, which was estimated to be a cost savings of approximately \$185,408 (USD) based on flight cost for one parent plus the child and the lodging and per diem for a 10 day stay.

3. The Pacific Asynchronous TeleHealth (PATH) Program

Over a 2 year period, the number of ECHO-Pac users at spoke locations increased, and more specialty providers at TAMC were requesting accounts, often finding it easier to reply to clinical questions using the asynchronous platform instead of receiving telephone messages and then trying to reach the asking clinician who might be in Japan, Guam, or South Korea. The success of the original demonstration project led to the renaming of the program to the Pacific Asynchronous TeleHeath (PATH) System in 2004.

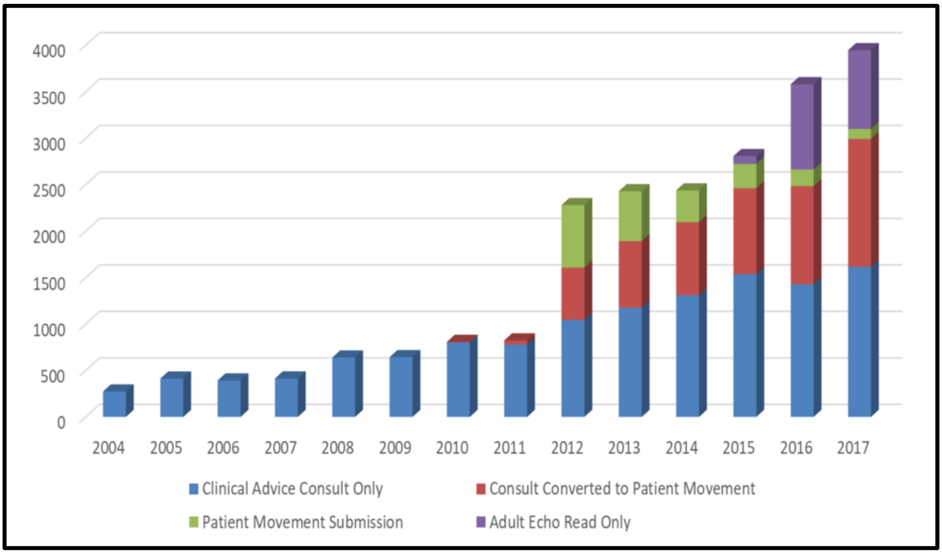

Figure 2. The Growth in Pacific Asynchronous TeleHealth (PATH): data showing the number of cases submitted from 2004 to 2017. The graph distinguishes between advice-only, patient movement to Hawaii, teleconsults that resulted in patient movement, and adult tele-echocardiogram requests.

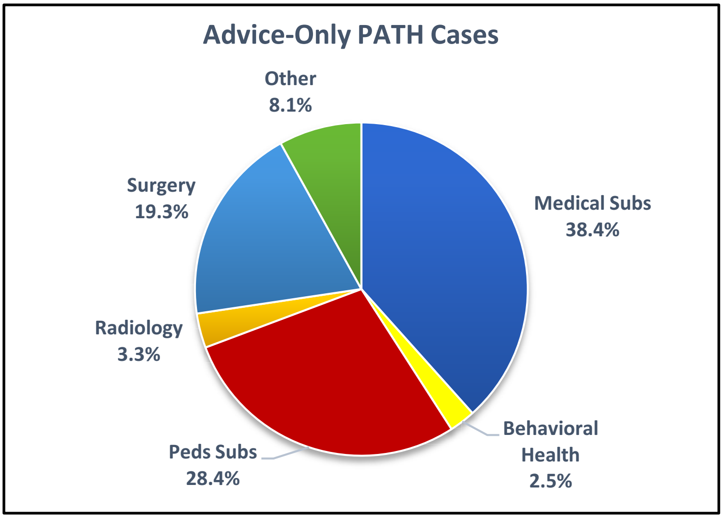

Figure 3. PATH advice-only cases (asynchronous teleconsultation) distribution across general medical specialty areas: adult medicine specialties, pediatric specialties, surgical specialties, behavioral health, and radiology. The group “Other” includes areas such as occupational medicine, pain management, and audiology *(data captured from 2017-2018 PATH case data).*

PATH expanded to include all age groups in 2009 due to continued request from end users at the spokes and the hub specialty providers, and then in 2012 the role of the system underwent a significant expansion by serving as both a tool for asynchronous teleconsultation and to coordinate appointments for either synchronous teleconsults or in-person visits at TAMC. By adding this care coordination functionality, PATH was able to improve the hand-off of patients who were coming to Hawaii. Prior to the use of PATH, the originating site provider did not have visibility of when specialty appointments or ambulatory procedures were available at TAMC, and many times patients would arrive at TAMC without pre-scheduled appointments, creating additional length of stay while additional appointments were worked into a specialty clinic. If a patient required an outpatient appointment with more than one clinical specialty at TAMC, this could exponentially increase the length of stay for in-person routine specialty appointments.

Table 1. Pacific Asynchronous TeleHealth (PATH) Specialties Available for Teleconsultation at Tripler Army Medical Center (based on 2018-2019 referral data).

Adult Specialties	Pediatric Specialties	Surgical Specialties	Other
Allergy/Immunology	Adolescent Medicine	Bariatric	Behavioral Health
Audiology	Allergy/Immunology	Breast Surgery	Chemical Addiction
Cardiology	Cardiology	Cardiothoracic	Interventional Rad.
Clinical Pharmacist	Developmental Peds	Colorectal Surgery	Musculoskeletal Rad
Concussion Clinic	Dermatology	Endo-Urology	Neuropsychology
Critical Care/Intensivist	Endocrinology	Facial/Reconstructive	Nuclear Medicine
Dermatology	Gastroenterology	Foot/Ankle	Radiation Oncology
Endocrinology	Genetic Counselor	Hand/Upper Extremity	
Endocrine/Fertility	Hematology/Oncology	Head & Neck	
Flight Medicine	Infectious Disease	Joint/Orthopedic	
Gastroenterology	Neonatology	Maxilofacial	
Genetic Counselor	Nephrology	Neuro-Otology	
Hematology/Oncology	Neurology	Neurosurgery	
Hospitalist	Occupational Therapy	Ophthalmology	
Infectious Disease	Pediatric Intensivist	Orthopedics	
Nephrology	Pediatric Psychiatry	Otolaryngology	
Neurology	Pediatric Psychology	Pediatric Otolaryng.	
Nutrition	Pulmonology	Pediatric Orthopedic	
Obstetrics/Gynecology	Physical Therapy	Pediatric Surgery	
Pain Medicine	Pediatric Radiology	Pediatric Urology	
Pathology	Rheumatology	Plastic Surgery	
Perinatology		Refractive Surgery	
Pulmonology		Spine	
Rheumatology		Surgical Oncology	
Sleep Medicine		Trauma	
Speech/ Pathology		Urology	
Sports Medicine		Urology Oncology	
Urogynecology		Vascular Surgery	
Vaccine Healthcare			

In 2015, PATH became the platform through which asynchronous adult tele-echocardiograms could be requested from the military hospitals on Guam and Okinawa, Japan. Both of these locations had radiology technicians who were trained in performing echocardiograms, and given clear parameters for clinical concern where they should immediately contact the patient's primary care manager and the cardiology service at TAMC. The addition of this routine service to both of these military hospitals further decreased the cost of regularly rotating a military cardiologist to these locations in order to perform routine, ambulatory echocardiograms. Figure 2 shows the growth in the volume of PATH cases from 2004 through 2017, showing that the two greatest changes to the volume were incorporating coordination for care if in-person evaluation in Hawaii was indicated and adult tele-echocardiogram requests. Figure 3 shows the distribution of the asynchronous provider-to-provider (advice-only) PATH cases, with adult medicine specialties capturing almost 40% of total case volume. The top five adult medicine specialties consulted in PATH for advice are: neurology, hematology/oncology, cardiology, gastroenterology, and endocrinology. For pediatric patients, the top five specialties consulted in PATH for advice are: pulmonology, cardiology, neurology, endocrinology, and gastroenterology.

As the demands on PATH grew, the need for a dedicated administrative team at TAMC also grew. In June 2018, then PATH medical director, COL Jennifer Mbuthia, stood up the Department of Virtual Health at TAMC, and the administrative management of PATH now fell under this new department, allowing for dedicated resources to continue to support this mission critical program for military medicine.

PATH continues to support approximately 1,500 active users, with over 4,000 cases submitted each year from around the Asia-Pacific, and over 60 different specialties available for teleconsultation, including surgical and radiology sub-specialties (Table 1).

3.1. Workflow Design

From the creation as ECHO-Pac, the asynchronous teleconsultation platform was designed to be low-bandwidth, and relatively intuitive to use. New users submit a request for an account using their military email address, and all requests are reviewed by the PATH team at TAMC to verify the requestor is a healthcare provider. If unable to verify the user, additional information may be requested. All PATH users have a unique username and password, and only need to have internet access in order to submit a new teleconsultation. The PATH homepage includes reminders that this is for routine teleconsultations only to mitigate the use of the platform for emergency medical advice that should be done over the telephone.

The design of PATH mirrors a hub-and-spoke model, with multiple spoke facilities submitting clinical cases that are all routed to the hub at TAMC. When a new case is initiated, minimum requirements include free text entry of clinical history and a clinical question being asked. The originating site provider can also attach images, scanned documents, or short video clips into the case if needed. Once submitted, the consult is given a unique case number, routed to the consult managers located at TAMC for review to verify information in free text is complete, then it is routed to the requested specialists. More than one specialist can be consulted on a case. Clinical comments are then provided, and any subsequent communication within the system follows along with discrete time-stamped text boxes. To facilitate end-user acceptance of the system, the times are displayed in their local time, and an email notification is also sent using only the PATH case number to inform them that a user has uploaded a new comment. Figure 4 shows an overview of the workflow described above.

PATH consult managers maintain visibility of all cases, and they are notified via email twice weekly of all cases that have not had a clinical response from the distant site/hub providers. This provides an added layer of accountability to insure timely responses to the teleconsultation.

PATH added the ability to submit pediatric pulmonary function test results from facilities that had the equipment and trained technicians to perform lung function testing on children. This could be done with or without a clinical question, especially if it was part of an annual asthma assessment on a child with well-controlled asthma who was being appropriately managed by their primary care provider.

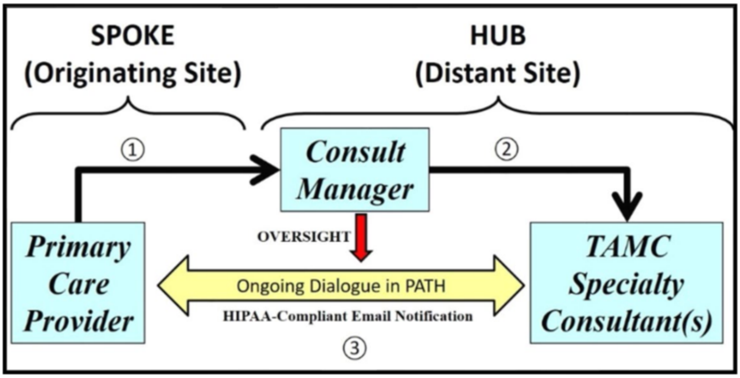

Figure 4. Overview of PATH workflow. (1) Case is created by clinician at the spoke, (2) reviewed by a PATH consult manager who forwards case to hub specialists (3)

3.2. Evaluation of PATH Impact on Care and Cost Avoidance: 2006-2009

A retrospective review of 1,000 pediatric teleconsultations from 2006 to 2009 demonstrated PATH system's positive impact with regard to access, quality, and cost, demonstrating the benefits of incorporating asynchronous provider-to-provider teleconsultation into routine pediatric practice [5]. Cases were reviewed by a panel of three pediatric providers, each independently completing a nine question survey after reviewing a case, and found that originating site providers achieved resolution of the clinical question 63% of the time. In addition, Mahnke et al found that the clinical question was looking for assistance in making a diagnosis in 72% of the cases, and asking questions regarding medical treatment in 21% of PATH cases reviewed.

3.3. Evaluation of PATH Impact on Care and Cost Avoidance: 2017-2019

As the clinical use of PATH continued to grow, assessing the impact it was having would be challenging if independent panels of reviewers were utilized. So in March 2017, the PATH system incorporated 2 survey questions for a user to reply to upon closing a case. The decision to limit the number of survey questions was rooted in finding a balance between obtaining data and end-users getting survey fatigue and not responding. Additionally, the responses gathered needed to have some meaning, or ability to link the responses or response trends to the value of the system. Value not only to the end-user/originating clinician, but also implied value to the patient by avoiding unnecessary travel and value to the organization by cost-avoidance [7]. The two questions were the following: (1) did this teleconsult prevented the need for patient movement? and (2) did this teleconsult recaptured care by preventing host nation/network referral?

In early 2020, TAMC Institutional Review Board (IRB) reviewed a research protocol to retrospectively review 3 years of responses to the two closing survey questions for all pediatric cases submitted. The consults assessed were submitted between March 2017 - February 2020, therefore the data did not include cases submitted after travel restrictions were implemented in the US due to the global pandemic from the severe acute respiratory syndrome-related coronavirus 2, or SARS-CoV-2.

The study data has not been published at the time this chapter was written, but the initial evaluation of the data for pediatric subspecialty consultations was presented at National Telehealth Research Symposium in November 2020. The PATH system captured basic demographics, location, providers, subspecialists, and response to the 2 survey questions. De-identified data were obtained for 2,448 pediatric teleconsults during the study period. Fisher's exact tests and chi-squared tests were used to assess differences in survey response, preventing face to face visits and recapture care rates. For users in the Western Pacific, over 40% of cases had completed survey responses for pediatric specialty cases, and over 69% reported that the teleconsultation did prevent the originating primary care provider from requesting to send the patient to Hawaii for routine specialty evaluation. Utilizing the similar assumptions as Mahnke used for his earlier cost avoidance calculations, this study further detailed estimated cost avoidance assuming a 9-day stay in Hawaii for routine ambulatory specialty evaluation. The presenting author estimated the cost avoidance during this 36 month window of evaluation to be over $3 million [8].

4. A Scalable Platform: Growth of PATH Beyond the Pacific

Based on the success of PATH in the Pacific, Navy Medicine East and the US Navy Bureau of Medicine and Surgery (BUMED) launched the Health Experts onLine at Portsmouth (HELP) teleconsultation system in June 2014. HELP was a sub-module built on the existing PATH platform and housed on the server at TAMC, but used to provide improved access to care, and to reduce the need for travel to a tertiary care center, for medical providers stationed in Atlantic Fleet and Europe [3]. By 2017, the HELP platform was expanded to medical providers who were deployed to the Middle East, making it the largest reaching teleconsultation platform in the DoD virtual healthcare system [4].

A two-year review of HELP's return on investment (ROI) showed considerable savings (both tangible and intangible) to the Military Healthcare System for relatively minimal cost by decreasing the medical provider's reliance on medical evacuation, most often from a ship, in questionable cases utilizing a low bandwidth, asynchronous, and internet accessible teleconsultation system [6]. This review looked at the first two years of this relatively new platform, but with only 559 cases they were able to use a physician review panel with three independent reviewers to assess each case. The authors only considered it an avoided patient movement if all three reviewers concurred, which did happen in 80% of the HELP cases. They identified 50 cases where all three agreed that a movement of the patient was avoided through the use of asynchronous consultation. To evaluate return on investment, cost savings were compared to prevented patient transfer for any medical reason from either the continental US or outside the US, tangible savings (defined by prevented costs of flights, per diems, and in person consult visits) and intangible savings (time taken from work). Such savings were then compared to the upkeep costs to maintain the HELP system (startup costs, administrative cost, provider time cost). The total tangible savings was estimated to be $693,461 (USD) for that 2 year review period, with an ROI of 81.15%.

In 2017, a PATH/HELP pilot project brought the platform to military medical providers deployed to the Middle East. Comparing the window before introduction of the system to a window soon after the platform was introduced, there was an estimated 56% reduction in routine (non-emergency) medical evacuations from the Central Command area of operations [4]. Although there were many complexities comparing data of evacuations in a combat zone, the platform was widely accepted and is still utilized in the Middle East by deployed military providers over 3 years later.

5. Summary

For over two decades, Tripler Army Medical Center in Hawaii has served as a telemedicine hub, responding to the need for provider-to-provider teleconsultations by finding a solution that was well-received by both the originating site and distant site providers. The user-friendly web-based portal allowed clinicians to submit or respond to clinical consults in a manner that was easily incorporated to their daily workflow, and did not disrupt or complicate their routine patient care. The expansion of this platform, which started out serving a pediatric population, was driven by the request of users. It was well-integrated in the overseas military medical environment prior to restrictions being placed on travel due to a global pandemic, and is a model that could be applied to healthcare service in civilian settings as well. This low-bandwidth, secure system demonstrated increased access to care in a method that was both time-efficient and cost-saving over the course of the 2 decades it has been used, and in various global settings [1,5,6,8].

PATH has shown that an asynchronous, provider-to-provider model of teleconsultations can be widely accepted across many different populations and medical specialty areas. The user-driven growth of the platform speaks volumes to the importance of a system that is simple to use, yet provides high-yield information. By allowing a provider at a spoke location to ask a specialist detailed questions specific to their patient, it gave high quality, patient-specific actionable advice. In many respects, PATH has become such a regularly utilized tool for military healthcare providers in the Pacific that it might be generating clinical consults that a primary care provider might not have thought to ask, but knowing how quickly they could get a response decided to seek a brief, virtual “curbside” with a specialist.

PATH serves as a model of teleconsultation that could be applied to other, non-military settings where travel distance hinders timely routine specialty care, or where the cost and complexity of synchronous teleconsultations might limit availability to specialty care. Future areas of review could include a comparison of PATH/HELP utilization before and after SARS-CoV-2 global pandemic, when global restrictions on movement into the US were placed for an extended period of time.

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Is Consent Not a Consideration for Instant Messaging?

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Abstract: Background. Recently there has been a steady increase in the use of Instant Messaging (IM) as a means of providing health and healthcare services. This growth has been particularly rapid during the ongoing COVID-19 pandemic. Many reports indicate informal services using IM, in particular WhatsApp, have arisen spontaneously, in the absence of any formal guidelines and little consideration of consent. This study documents the consent practices of healthcare professionals using IM for clinical activities in District Hospitals in KwaZulu-Natal, South Africa and compares these practices with the literature. **Methods.** As part of a larger audit of telemedicine activity in KwaZulu-Natal a survey questioned clinicians' use of IM, including consent practices and awareness of regulatory guidelines. Concomitantly multiple electronic databases were searched for papers on WhatsApp use in clinical service. Inclusion criteria were: papers written in English, reported on WhatsApp in clinical use or potential clinical use, and addressed consent. **Results.** The survey confirmed anecdotal reports of widespread informal use of WhatsApp in District Hospitals. Most clinicians were unaware of regulatory guidelines, and few obtained consent for taking photographs or sharing of images and information with colleagues for consultation. The literature review found that consent was mentioned in only 28 papers. Of these 11 reported that written consent was obtained, of which 5 were for taking photographs and 4 for sharing information with colleagues. **Discussion.** The survey showed that more than half of the respondents who used IM did not consider this to be telemedicine, with the corresponding ethical requirements governed by national guidelines, thereby risking legal exposure. However, South Africa's regulatory guidelines do not align with common clinical practice. The literature shows that the majority of doctors shared patient information by IM without obtaining any form of consent. **Conclusion.** Practical guidelines are urgently required in South Africa and worldwide that balance practical conduct of medical care with sound contemporary ethical principles. Prudent guidance will ensure clinicians do not inadvertently breach patient privacy and confidentiality laws whilst permitting continued health-related use of instant messaging.

Keywords. Instant Messaging, WhatsApp, consent, legal, regulatory, ethical

1. Introduction

The COVID-19 pandemic has seen a rapid increase in the use of telemedicine as a means of providing services while maintaining social distancing and complying with lockdown

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restrictions. Instant messaging (IM) and videoconferencing have been the most reported modalities. IM is the use of information and communication technologies (ICT) for text-based communication in which two (or more) persons participate in a single conversation using computers or mobile devices and the Internet for connectivity. Given that 'ICT for health' is ehealth (or now digital health), IM use within the health sector for clinical communications constitutes ehealth or digital health, and is a form of telemedicine. WhatsApp is the most used IM application globally [1], and for the purpose of this paper is used as an exemplar of IM. A PubMed search of the first 11 months of 2020 (January to November, inclusive), returned 273 papers on WhatsApp use, which is more than the total number of papers published over the previous three years and almost half of the all the papers on WhatsApp in PubMed.

A 2016 review of the use of WhatsApp in clinical practice found that consent was only mentioned in five of 58 papers and only obtained in three papers [2]. Many of the reviewed papers were from the developing world, and reported informal services that had arisen spontaneously and in the absence of formal guidelines for the use of IM in clinical practice. As a consequence, the lack of information on consent may reflect different ethical imperatives in the developing world. Subsequent papers from the developed world [3-6] have confirmed widespread informal use of WhatsApp and that consent remains an issue [4,7].

Consent for the use of IM in telemedicine has to address several issues: the sharing of private health information with another health professional or, in the case of chat groups, several people; the storage and security of this information on the sender's and recipients' phones; the secure transmission of the information; and compliance with any local privacy laws and telemedicine regulations.

There has been limited telemedicine activity in KwaZulu-Natal (KZ-N), a Province in South Africa, for nearly 20 years. The only formal telemedicine service provided by the KZ-N Department of Health, which is responsible for the provision of health services to over 80% of the population of more than 11 million people, is a teleradiology link between some regional hospitals and the tertiary care centres. A videoconference based teledermatology service has been run by the local medical school for many years [8]. There are no specialists at District Hospitals and there is anecdotal evidence of the use of informal, IM based telemedicine within and between doctors at these hospitals, and with specialist colleagues elsewhere in both the State sector and private practice.

The Health Professions Council of South Africa (HPCSA) is a statutory body tasked with, among other things, overseeing and regulating the ethical practice of medicine in South Africa. It has produced 'General Ethical Guidelines for Good Practice in Telemedicine' with onerous requirements for written informed consent for telemedicine [9,10]. Given that the use of IM for telemedicine was not considered when these guidelines were developed, and the limited evidence of patients consenting to IM use, there is need to understand current consent practice.

The aims of this study were to: document the consent practices of health professionals using IM for clinical activities in District Hospitals in KZ-N and to compare these with the literature.

2. Methods

2.1. Survey

As part of a larger audit of telemedicine activity in KZ-N a 24 item questionnaire was developed that addressed demographics, use of telemedicine in its different modalities, services for which it is used, services for which it is needed, consent and awareness of the HPCSA guidelines. The questionnaire was pre-tested by five people involved in telemedicine and medical informatics and questions were modified where necessary to avoid ambiguity. This paper reports, specifically, the respondents' consent practices and awareness of HPCSA guidelines when using IM for telemedicine.

The survey was carried out in late 2019, before the COVID-19 pandemic, at 25 of the 37 District Hospitals in KwaZulu-Natal, as District Hospitals do not have resident specialists. This study was undertaken at the request of the KwaZulu-Natal Department of Health eHealth Steering Committee. Ethics approval was obtained from the University of KwaZulu-Natal and the KwaZulu-Natal Department of Health ethics committees. All respondents consented to participate.

2.2. Literature review

In January 2019, the electronic databases PubMed, Scopus, Science Direct and six databases within EbscoHost - CINAHL with full text, Health Source Nursing/academic edition, Index to legal periodicals, PsycARTICLES, PsycINFO, and MEDLINE were searched for papers on WhatsApp in clinical service. The search term used for PubMed was "WhatsApp" [All fields] and for the other databases (("WhatsApp") AND ("telemedicine" OR "telehealth" OR "ehealth" OR "e-health" OR "mhealth" OR "m-health")) All fields. The search strategies differed because PubMed is restricted to biomedical related papers.

Inclusion criteria were: papers written in English, reported on WhatsApp in clinical use or potential clinical use, and addressed consent. Titles and abstracts were reviewed and papers that met the inclusion criteria were then reviewed. Book chapters, conference proceedings that were not full length papers, and papers on the use of WhatsApp for behaviour change, education, appointment reminders or medication adherence were excluded. All decisions on inclusion and exclusion were made by consensus of all authors. Data extracted included, year of the publication, country of origin, clinical service described and all information related to consent.

3. Results

3.1. Survey

There were 185 respondents from 25 District Hospitals, of whom 143 were doctors and 42 were allied health care providers (AHCPs). IM and/or chat was used by 136 (95%) of doctors for consultation, second opinion, and advice in a range of clinical services and by 40 (95%) of AHCPs for clinical activities and administrative functions. The specialties performed most by doctors were; dermatology, paediatrics, orthopaedics and burns, and for AHCPs were; dermatology, paediatrics, orthopaedics, burns, and radiology. Seventeen doctors used only WhatsApp chat groups. More than half of doctors who used IM and chat groups for clinical purposes did not consider this use to be telemedicine.

Respondents were asked if they were aware of guidelines for telemedicine practice from any of: the HPCSA, the South African Medical Association, the World Medical Association, the Medical Defence Union, or the National Department of Health. The question required a ‘yes’ or ‘no’ response for each option. Nearly two thirds (65%) of respondents did not answer the question. Only 18 (13%) of doctors using IM were aware of the HPCSA guidelines. Of the 18 who were aware of the guidelines and the requirement for written consent only two obtained written consent, five verbal consent, two considered consent to be implied, one did not obtain consent for IM and eight did not respond to the question about what form of consent was obtained.

Sixty-seven doctors (49%) who used IM, but were unaware of the HPCSA guideline requirements for consent, completed the question on the type of consent they obtained for IM. Only seven (5%) obtained written consent, and 46 (31%) obtained verbal consent, including 15 (11%) reporting that consent was verbal and implied. Nine doctors (7 %) considered consent to be implied. Five did not obtain consent for IM. Overall, fifty-nine doctors (43%) using IM did not respond to the consent question. Of the 17 respondents who only used chat groups, just one obtained verbal consent and one felt that consent was implied. Fifteen (88%) of those only using chat groups did not answer the consent question.

3.2. Literature review

The searches returned 590 unique papers. After review of the titles and abstracts, 167 met the inclusion criteria and after full text review, 28 papers that addressed consent remained. Of the 28 papers, only 11 reported that written consent was obtained of which 5 were for taking photographs [2,6,11-13], and 4 for sharing information with colleagues [2,14-16]. Three papers reported obtaining verbal consent [12,17,18], one of which was for sharing patient information [17]. Fourteen papers reported that consent should be obtained for taking photographs and/or sharing information with colleagues [4,12,19-30].

Although one study found most doctors considered that consent was required prior to taking a photograph [4], another reported only 42% of doctors obtained consent for smartphone camera use [6]. Another study reported that 63.2% of general dental practitioners did not obtain any form of consent from their patients for sending clinical materials for second opinion. The remainder obtained verbal consent [18]. In the Republic of Ireland, the General Medical Council’s guidance is clear on using visual and audio recordings of patients, stating recordings can only be made if appropriate consent is gained and documented. Despite this, 97% of doctors at a teaching hospital in Ireland shared patient information by IM without obtaining any form of consent [6].

Medico-legal providers recommend documenting consent in patient notes when sharing images on mobile phones [4]. Three papers mentioned the need for keeping a record of informed consent [21, 28], even if it was only verbal [6], and it was suggested that consent could be documented by submitting a photograph of the signed consent [21]. In an Australian study only half of respondents considered that consent needed to be documented in the patient notes or entered onto a hospital consent form [4]. Overall, there was uncertainty about any record keeping of informed consent [31], and general confusion existed regarding what consent was required when sharing patient information [4].

4. Discussion

The survey confirmed anecdotal reports of widespread informal use of WhatsApp in District Hospitals in KZ-N in a variety of clinical specialties for both one-to-one consultation and one-to-many chat groups. Chat groups were commonly used by both doctors as well as AHCPs for both clinical activities and administrative functions. Most clinicians were unaware of the HPCSA General Ethical Guidelines for Good Practice in Telemedicine (HPCSA guidelines), and its requirement for written consent and few of those who did, complied.

Ideally a patient should consent to a teleconsultation. Considering IM as another mode of teleconsultation, patients should consent to: any photograph being taken and stored on a local device; sharing of the image(s) with a doctor or group of doctors with accompanying clinical information; transmission of this content over the internet; and storage of that information on a device at the distant site. As a part of the consent process patients should be made aware of the security measures taken to maintain confidentiality and security of their data. The need to gain consent for all of these processes has been identified [32] but no reviewed paper discussed them.

Even though telemedicine was clearly defined in the questionnaire, more than half of doctors who used IM and chat in clinical practice did not consider their use of IM to be telemedicine. The implications of this are that these doctors would not see the need to comply with the HPCSA guidelines. This could have serious legal, regulatory and ethical implications in the event of a breach of patient privacy and / or confidentiality [7]. Conversely, abiding by current HPCSA guidelines is problematic, as noted below, and does not align with common clinical practice.

In Section 4.6.3 of the HPCSA guidelines [9] it is required that informed consent be in writing. Only two doctors, who were aware of HPCSA guidelines, obtained written consent, while most said consent was usually verbal or implied, similar to a study where only 36.7% of general dental practitioners obtained verbal consent from patients for sending clinical materials for second opinion [18]. This is also in line with a study of the consent practices of doctors and nurses conducting face-to-face consultations and then referring patients for further investigations or second opinions in KZ-N [33].

Further results from the survey showed that some respondents considered consent to be implied and six reported not obtaining consent. The implication of nearly half of respondents not answering the question on consent may be that they did not want to make known their lack of compliance, not only with the HPCSA guidelines [9], but also the Health Act of South Africa, Act 61 of 2003 [34].

Section 4.6.3 of the HPCSA guidelines [9] also requires informed consent to include the documentation of security measures taken for the use of telemedicine. In practice this creates a number of problems for doctors using IM. The security measures for IM are highly technical and difficult to translate into local languages [35], and a study in KwaZulu-Natal showed that only 35% of patients understood the meaning of the word consent in their mother tongue, isiZulu, and only 7% understood the word telemedicine [35]. Overall, the literature did not report on informed consent including security measures taken.

Section 4.6.3 of the HPCSA guidelines [9] further requires that the patient be informed as to who will be accessing their information. Again, this creates a number of practical problems. The doctor is sending patient information, text images and in some instances video and audio data to either an individual or a group of doctors. Ethically the patient should explicitly consent to this being done [25], with the exception of when the healthcare practitioner can justify the disclosure (which, arguably, is the case in every instance, since clinicians have a patients best interests as their focus). Although the survey did not address messages sent to a chat group nor the concern of improper disclosure, the literature shows that consent is seldom gained for sharing information [2, 35] and that confusion exists regarding what form of consent is required when sharing patient information [4].

In terms of the HPCSA requirements, both the referring as well as the consulted specialist must keep records of all electronic communications of a patient consultation for filing in the patient record. Again, the survey did not specifically ask how doctors stored patient data or kept records but medico-legal providers recommend documenting consent in patient notes when sharing images on mobile phones [4]. Three papers mentioned keeping a record of informed consent even if it was verbal, and it was suggested that consent could be documented by submitting a photograph of the signed consent form [21]. In one study only half of the participants (doctors or medical students) considered consent needed to be documented in the patient notes or entered onto a hospital consent form [4].

Consent is the expression of the fundamental ethical principle of autonomy. The lax consent practices of doctors as evidenced in this paper, and in many parts of the world, when using IM in clinical practice is a major concern that needs to be addressed.

5. Conclusion

Instant messaging is widely used in KZ-N, South Africa, and even prior to COVID-19 its use for telemedicine services had been rapidly growing globally. This study shows evidence of widespread uncertainty, even confusion, regarding what type of consent (explicit vs implied; written vs verbal) is required when sharing patient information using IM. This has created a laissez faire approach to consent and health-related IM use.

Within South Africa the HPCSA guidelines are not helpful in this regard being formulated prior to development and use of IM in healthcare. These guidelines urgently require updating by balancing practical conduct of medical care with sound contemporary ethical principles. This need also requires addressing elsewhere in the world. Prudent guidance will ensure clinicians do not inadvertently breach patient privacy and confidentiality laws whilst permitting continued health-related use of WhatsApp and other instant messaging applications.

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Web-Based Cardiac Rehabilitation: A Co-Design Workshop

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Abstract. Background. Only 20-40% of candidates actually attend cardiac rehabilitation programs in Australia, with attendance numbers remaining unchanged in the last 20 years. Common barriers to cardiac rehabilitation are geographical isolation, work responsibilities and transportation. Web-based cardiac rehabilitation can provide an alternative, patient centred, flexible delivery option. **Objective.** The objective of this study was to describe how patient-generated input, through a workshop on desired content and features, informs technology and implementation specifications for the patient portal of a cardiac rehabilitation website. **Methods.** *UX Design* theoretical framework, using a co-design workshop, with thematic analysis and a survey. **Results.** We recruited 7 participants and 1 cardiac rehabilitation coordinator. The median age of participants was 75.0 (IQR 74.0-78.0), 4 (57.1%) were male and all had completed a cardiac rehabilitation program. Most used a smart phone (5, 71.4%) and Facebook (6, 85.7%). Four themes were identified: input information, format of information, usability and support of health behavior change, informing the next iteration of the workshops and contribute to the cardiac rehabilitation patient website development.

Keywords. Cardiac rehabilitation, co-design, web-based, remote health

1. Introduction

Cardiac rehabilitation (CR) is the sum of interventions needed to ensure the best physical, psychological, and social conditions, slowing the progression of cardiovascular disease, and restoring quality of life. There is high-quality evidence that CR significantly reduces death, reoccurring cardiac events and improves quality of life, empowering people to better understand and take charge of their health [1]. In rural and remote Australia, low referral rates, scarcity of health professionals, poor perceptions around the benefits of CR, lack of flexibility in the delivery of CR programs and geographical isolation are major challenges to CR attendance [2,3]. Recent studies have shown that only 20-40% of candidates attend CR programs [1]. Furthermore, the practice of and attendance at CR in Australia has not changed in the last 20 years [4].

CR is predominantly delivered face to face or via telephone. Individual studies have had positive outcomes when exploring and trialling web and app-based models. An Australian study reported improvements in CR adherence (94% vs 68%) and completion (80% vs 47%) using a smart phone home-based care model [5]. Likewise, an online program of CR implemented in the UK showed positive results across clinical and psychosocial outcomes such as improvements in angina frequency ($p = 0.002$), physical activity (+497 steps intervention group, -861 steps control group) and emotional quality

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of life ($p = 0.04$) [6]. Web-based CR can address the issues relating to the rigidity of current CR delivery models and distance-related barriers.

This study will contribute to the development of a patient portal, within the https://www.chapproject.com.au/ website, with password protected login. The patient portal will include interactive secondary prevention advice, daily reminders to exercise, and private password protected messaging with a CR specialist. It will also incorporate the recording and monitoring of data, including objectively collected activity data via smartphone or bluetooth device. Providing a flexible and tailored approach to CR.

2. Objectives

The co-design process involves human centered design, ensuring a patient centered care model that meets the needs and abilities of the people who will ultimately use and engage with it [7]. The objective of this study was to describe how patient-generated input, through a workshop on desired content and features, informs technology and implementation specifications for the patient portal.

3. Methods

3.1 Participant Recruitment

Participants who have completed or currently undertaking a CR program within the regional Local Health Network were recruited via the local CR coordinator, who approached potential participants, providing them with the Patient Information and Consent Form.

3.2 Study design and setting

This study was conducted at the Flinders University Rural School in the Limestone Coast Local Health network. Patient consent was obtained prior to beginning the workshop, inclusive of audio recordings. Participants were eligible for inclusion based on their current or past inclusion in a CR program. The workshops used the *UX Design* theoretical framework, gaining critical feedback and insights from participants. We also assessed participant satisfaction with the website with a validated satisfaction survey on completion of the workshop.

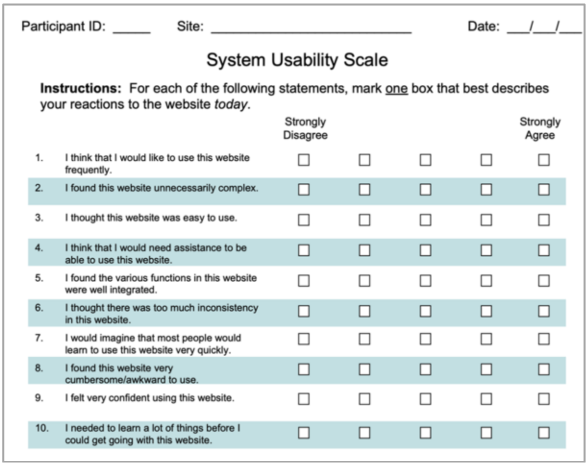
UX stands for *user experience*, and aims to create a positive user experience, resulting in consumer ready products, involving end-user's holistic engagement with the project at any and all points on a continuum [8]. UX workshops are guided by three main components: goal setting, questions, and activities [9]. Workshops under the UX design method use a set of principles and practices that allow researchers to identify problems or themes and create solutions and innovation.

Sample sizes for formal usability studies typically require 10-12 participants, with less formal usability studies 4-5 participants [10]. Usability studies have found that 80% of problems and actionable feedback are found from the first four participants [10]. Based on this, we aimed to recruit 10 participants per workshop, overrecruiting by 2 participants, allowing for attrition. Our final sample size was 7 participants.

3.3 Instruments

Participants were asked to fill in the demographic questionnaire at the workshop, including their age, gender, country of birth, education level, occupation, heart condition and attendance at CR. They were also asked about their relationship with information technology, including their social media platform, Internet connection and most common device.

On completion of the workshop, they answered the System Usability Scale (SUS) (Figure 1). The SUS provides web designers with a quick and reliable way to determine the subjective usability of the developing website with a valid tool (*a* 0.7-0.9) [11].



Participant ID: _____ Site: _________________________ Date: ___/___/___

System Usability Scale

Instructions: For each of the following statements, mark one box that best describes your reactions to the website *today*.

		Strongly Disagree				Strongly Agree
1.	I think that I would like to use this website frequently.	☐	☐	☐	☐	☐
2.	I found this website unnecessarily complex.	☐	☐	☐	☐	☐
3.	I thought this website was easy to use.	☐	☐	☐	☐	☐
4.	I think that I would need assistance to be able to use this website.	☐	☐	☐	☐	☐
5.	I found the various functions in this website were well integrated.	☐	☐	☐	☐	☐
6.	I thought there was too much inconsistency in this website.	☐	☐	☐	☐	☐
7.	I would imagine that most people would learn to use this website very quickly.	☐	☐	☐	☐	☐
8.	I found this website very cumbersome/awkward to use.	☐	☐	☐	☐	☐
9.	I felt very confident using this website.	☐	☐	☐	☐	☐
10.	I needed to learn a lot of things before I could get going with this website.	☐	☐	☐	☐	☐

Figure 1. System Usability Scale [12]

At the end of the workshop, the participants were asked to fill in an evaluation form and supply feedback. This evaluation form included 11 questions; these were divided into two parts. Part 1 sought feedback about what they liked, did not like and what interested them most out of the event. Part 2 sought feedback, based on a Likert scale, on the venue, food, audio visual, length, content, and presenters.

3.4. Data collection and analysis

The workshop was audio-recorded and transcribed. The workshop activities facilitated data collection and included focussed discussion about the format, within the website, participants preferences for receiving education, such as written (pdf/print, video, animation) and the CR Modules. The website's usability was explored through access to the website user interface design (Figure 3-5). Further to this the website's usability was assessed with set cues guiding discussions with questions such as: *Could you use it without help?*, *Is the navigation of the website clear? Is the language clear and easy to understand?*, and *Does it look good?*

These questions were responded to with sticky notes, with participants encouraged to share their responses when placing on the white board. Photographs of the white board and field notes were taken for later reference. The website's usability was assessed with the SUS [11]. Baseline data was collected through a questionnaire prior to the workshop.

The audio recordings were transcribed verbatim by the first author and then analysed using thematic analysis, which allowed themes to be generated from the data, and then organized into higher-order themes. Further, analysis from the post workshop SUS, assessed the patients' perception of the website in terms of audio, visual, content, usefulness and user-friendliness. Baseline data (nominal) from the demographic questionnaire is presented as frequencies (n) and percentages (%).

3.5. Ethical approval

All eligible participants provided informed consent before the workshop. Ethical approval was obtained from the Southern Clinical Human Research Committee (SA HREC) and the Southern Adelaide Local Health Network Director, Office for Research (266.20), from the 23 October 2020 till 23 October 2023. Site specific approval was also granted (EGR/20/RSS/15-19).

4. Results

4.1. Participant characteristics

The characteristics of the participants are given in Table 1. Out of the 8 participants eligible and consenting to be involved 7 participated. The median age of participants was 75.0 (IQR 74.0-78.0). There were more male than female participants (4, 57.1%). The majority were adequately educated with only one participant having completed their education at primary school level (1, 14.3%). All the participants were retired (7, 100%) and had completed a CR program (7, 100%).

Table 1. Participant demographic characteristics

Characteristics	Descriptive Statistics, n=7 (%)
Age, median (Interquartile range)	75.0 (IQR 74.0-78.0)
Sex	
Male	4 (57.1)
Female	3 (42.9)
Country of Birth	
Australia	5 (71.4)
United Kingdom	2 (28.6)
Education Level	
Primary school	1 (14.3)
Secondary school	3 (42.9)
Certificate	2 (28.6)
Bachelor's degree	1 (14.3)
Occupation	
Retired	7 (100.0)
Cardiovascular Condition	
Acute Myocardial Infarction	6 (85.7)
Heart Failure	1 (14.3)
Cardiac Rehabilitation	
Yes	7 (100.0)

Participants information technology characteristics are given in Figure 2. Facebook (6, 85.7%) and Twitter (2, 28.6%) were the most used social media platforms. The National Broadband Network (NBN) was used by just over half of the participants (4, 57.1%) and the majority used a smart phone (5, 71.4%).

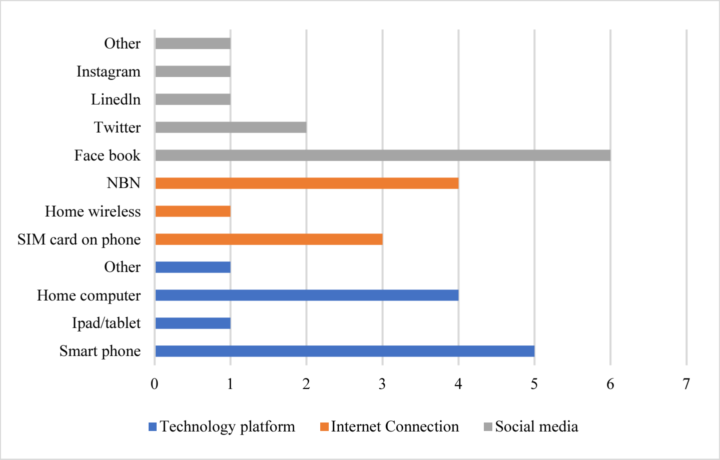


Figure 2. Information technology characteristics

5. Overview

From the workshop presentation and discussion, a total of 4 themes were identified that reflected participants concerns and ideas: *input information, format of information, usability* and *support of health behavior change.*

5.1. Input Information

Initially participants were shown a design page and log in page for the website (Figure 3) with some background discussion regarding the three models of CR, face to face, telephone or web based. It was highlighted that the starting point for choosing web-based CR was through the CR coordinator. From this one participant stated a, *'step by step guide for registration, with a help contact number'* would help if they found the process overwhelming or confusing.

Further to the above discussion the use of wearable devices was discussed by a couple of participants when viewing the slide shown in Figure 4. They said: *'given an apple watch as a gift, it is surprising some days how little we do'* and- *'iPhone health app, I use it sometimes,'* which then led to another participant asking about those people who do not/would not use a wearable device, *'How else can activity be measured if no watch or app is used?'*

Following on from this the participants observed the slide in Figure 5, which created discussion around the human element of consistency in information being input. One participant commented on this specifically stating the need for: *'personal accountability to enter information and complete tasks.'* Which led to participants querying the dials on the screen reflecting health status. Another participant wanted to know how the reading for mental health under care plan was obtained, asking: 'mental health information, how will this work?'

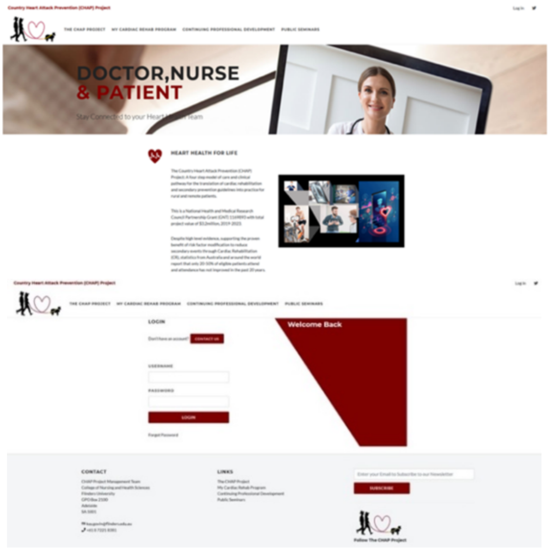


Figure 3. Design and log in pages

Figure 4. User interface design example

Figure 5. User interface design example

There was some general discussion about other information that could be input into the patient portal with one participant reflecting on their use of the notes feature on their smart phone asking: *'could it have a notes section like you have in a smart phone?'*

5.2. Format of information

There was a lot of discussion and reflection after the presentation was complete with participants talking about what would make the information in the website interesting and relatable. Some comments around this theme were:

- *'videos-pharmacist, cooking, dietician'*
- *'written information available from the video/audio information'*
- *'animation of a normal heart and different procedures'*
- *'links to the Heart Foundation books'*

5.3. Usability

Within this theme there was a significant comment by one participant, stating. *'Consider platforms the website is available on (not just desktop/laptop)'* Another participant expressed concern, if they were to use the web-based CR option, due to*, 'not confident understanding information.'* As this concern was discussed it related to the elements seen in Figures 3-5.

5.4. Support of health behavior change

The participants felt the website would be a positive tool for behavior change, with three participants highlighting the areas they recognized as important:

- *'activity is exercise, keep doing something every day'*
- *'medication reminders are important and often get forgotten'*
- *'support when unable to speak to/appointment with CR clinician'*

Finally, an important component to health messages was around food, specifically that they are positive. One participant highlighted the need for the subtle reversal of dietary information, stating: *'dietician to tell us what we can eat not what we can't eat.'*

5.5. Website evaluation

The website's usability was evaluated using the SUS, with a mean SUS score of 58.7 (SD 19.2) (Figure 6). The SUS is scored from 0-100, with a score 68 indicating okay usability, 68-80.3 good usability and >80.3 excellent usability [12]. There were 8 SUS completed as the CR coordinator attending the workshop also completed one. Of the 8 SUS completed 2 were incomplete, with > 8 answers not completed. These unanswered scores were then scored at 3, per the SUS scoring criteria [12].

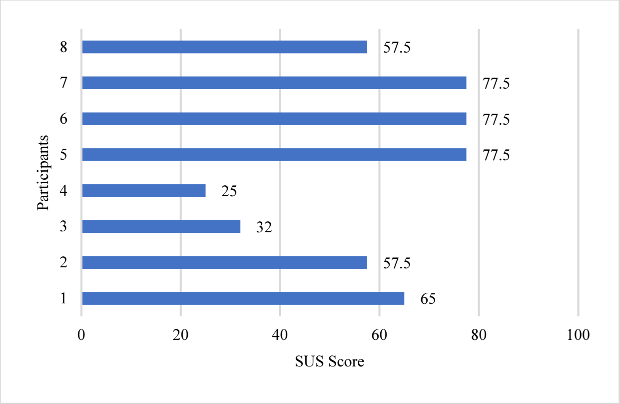


Figure 6. System Usability Scale

6. Discussion

For this study we organized a co-design workshop which was attended by people who participated in a CR program following a cardiac event. Participants were predominantly male and older age. Most participants owned a smart phone and used one social media platform. There is no readily available Australian data on elders use of smart phones and social media. However, one study from the United States (US) looking at the relationship between Facebook use, loneliness, social satisfaction and confidence with technology, reported a much lower percentage of Facebook users (42%) compared to non-Facebook users (58%) than in this study [13].

During this workshop the participants had the opportunity to see the user interface designs of the patient CR website and share their ideas, express their concerns and inform on how elements could be improved. This workshop identified themes and generated ideas from the process of how information is input to users for ease of navigation, particularly in the initial stages of commencing CR. The themes and ideas that emerged were *input information, format of information, usability* and *support of health behavior change* (Table 2).

The website's usability was assessed by the SUS, with an average score reflecting less than okay usability. However, the individual participant total scores represented a 50% response rate for okay usability. The SUS merely gives us a measure of the website's usability in this early development phase. Looking at the individual responses is irrelevant, as it does not offer up anything actionable, it is only diagnostic, as seen in the SUS questions [14]. Participants in this study are representative of the CR population, by age, and gender providing the researchers and web developers with feedback from the population most likely to access CR. Furthermore, our sample size is consistent with the literature for UX Design workshops with actionable feedback obtainable from as little as four participants. However, there is a lack of cultural and language diversity, limiting the feedback to only English-speaking populations. Finally, the SUS scores do not accurately reflect the website's usability given two participants had not completed every answer and only a modified score was achieved. It is expected with further iterations of the website's development, when presented at future workshops, this score will improve.

Table 2. Workshop themes and developments

Patient comments/needs	Features and functionality developments to respond to the patients' needs
Input information	
'Step by step guide for registration, with a help contact number'	Different forms of tutorial on the use of the portal: video, pop-up messages on the screen, written tutorial Helpline for patients through chat or telephone Cardiac rehabilitation coordinators explaining the use of the portal for those attending face-to-face
'Given an apple watch as a gift, it is surprising some days how little we do'	Engage with Cardiac nurses and the CR team to promote to patients the use of freely available activity trackers apps Collecting data of activity trackers through the portal (e.g. Bluetooth technology) Giving feedback to patients on their weekly level of activity through push notifications/SMS Having a graph where patients can follow-up their activity progress on a weekly basis
'iPhone health app, I use it sometimes'	Engage with Cardiac nurses and the CR team to promote to patients the use of freely available activity trackers apps Collecting data of activity trackers through the portal (e.g. Bluetooth technology) Giving feedback to patients on their weekly level of activity through push notifications/SMS Having a graph where patients can follow-up their activity progress on a weekly basis
'How else can activity be measured if no watch or app is used?'	Collecting data on daily living and leisure activities rather than exercise only data (e.g. patients being able to report they did 30 min of gardening/week) Import data from wearable tracker to patient portal
'Personal accountability to enter information and complete tasks'	Use of objective questionnaires to collect data Progress bar to indicate completed tasks/ yet to do
'Mental health information, how will this work?'	Use of validated questionnaires
'Could it have a notes section like you have in a smart phone?'	Have the content organized on the portal as daily or weekly tasks to patients (e.g. eat 5 pieces of vegetable/day as a daily task) Have a calendar in the portal where patients can access their daily or weekly tasks Have a functionality that allows patients to input personal tasks and tick the completed ones
Format of information	
'Videos-pharmacist, cooking, dietician' *'Written information available from the video/audio information'* *'Animation of a normal heart and different procedures'* *'Links to Heart Foundation books'*	Minimize the use of texts Deliver information through short videos and animations Have references to My Heart My Life book on the portal (e.g. learn more about this on Page X of My Heart My Life) Use of videos from reliable sources such as Heart Foundation
Usability	
'Consider platforms the website is available on (not just desktop/laptop)'	Consider designing the portal for smartphones and tablets as a priority
'Not confident understanding information'	Use of plain language Reassuring patients that they can access content as many times as they want even after having completed a specific module
Support of health behavior change	
'Medication reminders are important and often get forgotten'	Collect data on medication and times of taking the medication Patients can choose to receive push notifications/SMS at the times they are taking their medications
'Support when unable to speak to/appointment with CR clinician	Create a private chat on the portal through which patients can message CR clinician Peer support function (forum)
'Activity is exercise, keep doing something every day'	Collecting data on daily living and leisure activities rather than exercise only data (e.g. patients being able to report they did 30 min of gardening/week)
'Dietician to tell us what we can eat not what we can't eat	Invite patients to make videos with recipes to be displayed on the portal

The workshop provided critical information for the next iteration of the CR website development, particularly highlighting the need for elder friendless for ease of website navigation and connectivity, with a CR clinician at commencement and throughout the formal program. This finding is consistent with a report from the US stating that 73% of people over the age of 65 in the United States are connected to the web [13]. Suggestive of a demographic that could be a captive and capable audience for web-based CR.

This workshop will inform the next iteration of the patient CR website development, providing structure for future UX Design workshops, enabling the next level of participant feedback.

Acknowledgements

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Conflict of Interest

No conflict of interest

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Virtual Care: The Future for Telehealth

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Abstract. The COVID-19 pandemic has brought telehealth into the limelight. Telehealth is not a new word but since the pandemic, for many day-to-day users of the healthcare system, this term has become a household term. For IT enthusiasts, it is refreshing to see the uptake in telehealth. In most cases the uptake in telehealth came from the forced necessity of minimizing the spread of the virus. The positive outcomes have taken healthcare by surprise. It is not surprising then to see healthcare service providers transitioning to telehealth at an exponential rate. However, the upcoming COVID-19 normal state will demand more than the transitioning of 'brick and mortar' clinical practices to video or tele consult, making telehealth a natural predecessor of virtual care. This is a position paper presenting the current state of telehealth by outlining its benefits, limitations, looking beyond telehealth to address some of the recurring healthcare pain points and potential solutions to move towards patient-centered care via the adoption of virtual care.

Keywords. Telehealth, virtual care, healthcare pain points

1. Introduction

Australia's health system is one of the best in the world, providing safe and affordable health care for all Australians. COVID-19 has forced the health system to rapidly embrace telehealth practices and technologies. In most cases telehealth is simply transferring what used to happen in person (e.g. a consultation with a health professional) to an online format to create a short-term workaround. However, stop gap solutions mean patient experience can be poor, unengaging, sessions may be insecure, and data potentially compromised. In the current pandemic, the technology rather than the medical interaction and advice has become the focus. Therefore, there is an urgent need for the health sector to move away from telehealth to the broader concept of virtual care, where a broader range of health activities can be virtual.

Australian healthcare needs innovation and virtual care is one powerful modernization that does not require dramatic disruption to our existing systems. Virtual care does enhance, improve and complement traditional care. The term "virtual care" is an umbrella term [1] for a wide variety of terms that are used to describe the various ways and means that health care may be provided from a distance. Virtual care encompasses the commonly used terms of telehealth and telemedicine (defined below) yet is broader and not limited by these terms:

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i. telehealth - the use of telecommunication techniques for the purpose of providing telemedicine, medical education and health education over distance [2, 3]

ii. telemedicine - use of advanced telecommunication technologies to exchange health information and provide health care services across geographic, time, social and cultural barriers [2, 4]

The purpose of virtual care is to improve our healthcare systems – that is the "organization of people, institutions, and resources that deliver health care services to meet the health needs of people" [5] whilst constraining the ever-increasing costs of healthcare. Virtual care is the delivery of health care over a distance using various forms of communication or information technologies [6, 7] and where traditional face-to-face care delivery is complemented with technology enabled remote care. Virtual care may be from clinician to patient, patient to mobile technology or healthcare provider to healthcare provider. Hence, virtual care is a broad term for all the digital tools and real-time communication, to enable health providers to remotely interact with the patient.

Australia is well placed to advance virtual care, with the maturing adoption of electronic health records including the national MyHealth Record facilitating access to patient health information, with permission, from anywhere. Interoperability of electronic health records is an essential component of virtual care and enables integration of communication platforms and patient health information within virtual consultations.

This position paper views virtual care through a wide lens by considering continuity of care outside of acute care environments, e.g. at home, in aged care facilities, and primary care. It provides insight into common healthcare pain points that could be addressed by looking beyond telehealth.

2. Benefits of telehealth

There are numerous benefits of moving to the virtualization of communication that telehealth provides. The most obvious and well reported is that expansion of access to care and the move to a more on-demand model convenient to the patient [8]. Indeed, disease specific examples of the success of telehealth, for instance in cancer care [9] demonstrate the benefit in patient monitoring and management for earlier detection of complications. This in turn leads to better patient outcomes and lower costs from reduced hospitalizations [10].

For health professionals, telehealth visits are more efficient [11] and help doctors make use of unused time and see additional patients [12] which in turn brings a higher income for private practices. The convenience of being able to attend a consultation without the need to travel to a health facility means the likelihood of no-shows or cancellation of appointments by a patient is lower, enabling better efficiency for the practice.

Improved efficiency will have flow on effect for patients, health professionals and the overall healthcare system. This will contribute improved patient satisfaction, improved relationship between all parties involved in the care pathway, improved quality of care as a consequence of operating in a less chaotic environment, improves overall productive within the healthcare sector, enable innovation and more importantly; it will enable availability, accessibility and equitable healthcare.

3. Limitation of telehealth

What is urgently needed is to redefine telehealth so that it is broader, more data-intensive and ultimately designed to deliver a superior patient and clinician experience and outcomes. Whilst telehealth has been with us in Australia for some time, particularly for remote healthcare, it is vastly underutilized and not broadly incentivized by our healthcare funding models. The predominant issue is the lack of widespread use and adoption of telehealth.

The need to improve poor health outcomes in rural and remote communities in Australia is well recognized. Whilst telehealth and telemedicine have been widely used in Australia over the past decade as a means of overcoming problems of access to health care and the shortage of health professionals in rural and remote areas [13], in many cases, telemedicine and telehealth are used to augment other service delivery models [14]. Effective and patient-centred care requires patient engagement, resource and care coordination, and a “new” patient-physician relationship [15]. Where telehealth replaces the consultation element, it does not encompass a holistic experience for the patient. The barriers that telehealth addresses, particularly for rural and remote areas, are a huge step in reducing the inequity in access to healthcare services [16]. However, many of the barriers that exist with lack health providers, lack of coordinated and integrated care opportunities are not overcome using telehealth alone. The need for adjunct services to support telehealth, to connect to local community services and to expand the range of services that can be provided [16] means that a virtual care approach is essential.

A simple example involves the process of getting a prescription. A patient may experience the convenience of a telehealth visit but then has to visit the clinic to collect a prescription [17], thereby undoing any benefits gained in reducing travel time and its associated cost. COVID-19 has accelerated the uptake of electronic prescribing in Australia, however the technological challenges inherent in updating and integrating disparate clinical desktop, mobile and pharmacy software may see national-wide implementation delayed. Another example is the use of sensors to monitor vital signs, especially in the management of chronic disease. The continuous data collected does not flow directly to the doctor [18] due to the lack of platforms that enable end-to-end integration. Care fragmentation is quite common when patients receive care from multiple health service providers; what is needed is innovations in electronic medical records and clinical systems that are interoperable enabling seamless data sharing between multiple service providers. One of the main improvements needed is a model of care delivery and clinical systems that integrates consumer technology (e.g. wearable, smartphones, mobile apps, sensors) with electronic medical records that captures remote monitoring data and patient vital signs to give a holistic picture of a patient’s health. Improvements in remote monitoring and collection of vital signs outside of clinic visits are critical in the management of mental health and chronic disease, especially in the older population. Some of the main barriers to the uptake of telehealth reported by older participants (mean age=68) are technical problems, believing that telehealth is not necessary and preference for in-person care [9]. These barriers can be addressed by enabling on-time technical support [9] and delivering educational initiatives to reduce anxiety around technology use. In addition, we have seen anecdotal reports on the older adults willingly embracing technology during the pandemic motivated by the desire to stay connected with family and friends.

4. Beyond telehealth: opportunities to address recurring healthcare pain points

Australian healthcare faces many recurring challenges in delivering care (Figure 1). These challenges fall in to two broad categories: those related to the context of care delivery (A-C) and those related to the logistics associated with the delivery of care (E-G).

Figure 1. The recurring challenges in healthcare delivery in Australia [19].

There is an ongoing need to improve poor health outcomes in rural and remote communities in Australia through improved access to health services. The time is ripe to build upon the significant achievements in relation to innovative models of Primary Health Care since the first National Rural Health Strategy [14]. Often these isolated rural and remote communities are too small to support traditional models of health delivery locally, so residents must access care from larger urban centres. Unfortunately, access to health services provided in larger centres remains a problem for many residents of isolated settlements [14]. Essentially what is needed is a change at policy level to enable the adoption of patient-centered primary and community care [20] and a review of primary care cost model.

Telehealth services in rural Australia has been supported by the Medicare Benefits Scheme (MBS) for psychiatry since 2003, for specialist services since 2011, and for rural GP services since 2019. In response to the COVID-19 pandemic, the Australian Government extended the funding for telehealth services to consultations between patients and their general practitioners, mental health providers and medical specialists, and to midwives. It is now considering how telehealth can be used by any healthcare provider (including allied health) in the future. The opportunity to investigate how virtual care could impact costs of the healthcare system in Australia is a vital piece in improving patient outcomes whatever the drivers, be they patient demand, pandemics, or embracing new care pathways enabled by technology. Given the complex nature of the Australian healthcare funding model, cooperatively operated by all levels of Australian government – federal, state and territory, and local. Added to this, maintaining world-class, safe and affordable healthcare for all Australians, means we need to look for new and alternative, data and technology supported, ways to shift (rather than transform) healthcare in Australia.

The rise of COVID-19 has not diminished the normal demand for the health system to manage chronic diseases and emergency situations. There needs to be a continued focus to keep people with chronic illness and comorbidities healthy and out of hospital. Coupled with the need for social distancing, public and private funding models need to expand to fund doctors, nurses and allied health professionals to deliver care, where clinically appropriate, virtually. These measures support people who require medical care, who may have high levels of anxiety due to the crisis, to seek treatment and care as well as help to protect transmission of the disease through the healthcare workforce [21]. Delivering care virtually by keeping clinically appropriate patients out of acute care settings will prevent negative patient outcomes associated with ambulance ramping and prolonged waiting times to receive treatment at emergency departments.

There are numerous opportunities to improve health care service provision for older patients via virtual care. Remote care and monitoring for older patients will prevent unnecessary hospitalization and reduce the occurrence of delirium which commonly sets in hospital environment, adverse events from medication errors, falls associated with confusion and polypharmacy. One of the biggest advances comes from real-time monitoring as seen in the reductions of severe hypoglycemia and improved quality of life [22].

There are several pain points for mental health patients presenting at emergency departments, such as prolonged waiting times due to mental health bed shortage, increased hospital length of stay, which is disproportionate to their lower acuity level, increased use of restrictive intervention and more than half of the presentations are repeat presentations [23]. The pandemic has seen a surge in telehealth mental health service delivery which has dramatically reduced the strain on the healthcare system. Although adverse events such as suicide has not increased in Australia as a result of the pandemic, the real effect of the pandemic is yet to be seen in years to come, and requires long term preparedness by going beyond video and tele consult. Opportunities in virtual care will arise from technological innovation in integration of consumer wearable, remote monitoring, and early intervention alert system for crisis management.

5. Move to patient centered care

The benefits to patients and supporting patient-centered care, particularly for routine treatment of chronic conditions is clear [15, 18]. This is supported by the increasing set of digital services and health monitoring that can be at home [24, 25]. This leads to healthcare delivered more conveniently for the patient, often eliminating travel time and costs and minimizing waiting times. Also, of considerable benefit to the patient, is the ability to include multiple healthcare providers, allied health providers and family and carers in one consultation. This encapsulates a more personalized and proactive approach to care for the patient, thus potentially resulting improved experience and outcomes.

From connecting by video to virtual reality, augmented reality and extended reality for education and simulation, to therapeutics within the operating room are all examples of innovation in virtual care which are centered around providing better care outcomes for the patients. For those of us fortunate enough to be living within first-world healthcare systems, brick and mortar hospitals will become more decentralized over the next five years. It is already happening in the UAE and with Kaiser Permanente. Healthcare provider in these examples already have many of their patients using wearables, transmitting data to providers via the cloud and patient data can be accessed from anywhere on demand.

6. Potential solution

To achieve a new and effective virtual care environment demands innovative and comprehensive solutions to integrate and blend technologies to improve the experience. As demonstrated in Figure 2, these solutions need to be scalable, interoperable, and use secure infrastructure. More than this, they need to incorporate how patients and providers can use these solutions, integrate into clinical and care processes, as well as make effective use of existing technology. What is needed is a longer-term perspective to improve clinical care models, improve the patient experience, reduce costs and improve patient safety. The use of augmented reality and virtual reality in consultations could provide a much richer experience.

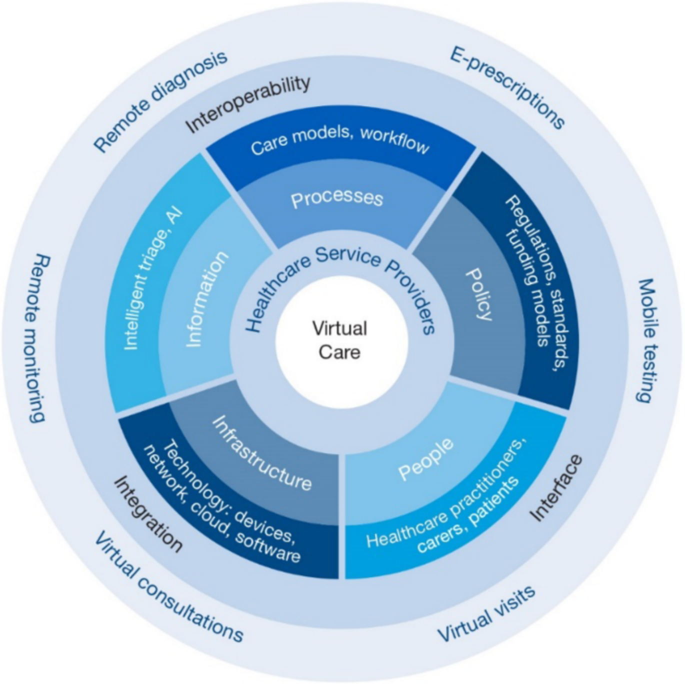

Figure 2. The construction of virtual care and its components [19]

Solutions need the combination and integration of technology, care models, workflow, workforce skills, funding models, policy, standards and guidance. Since 2009 over 80 commercial telemedicine companies have entered the market [26], with the majority catering for low-acuity issues. However, many of these solutions do not use primary care physicians so there is disconnect between commercial solutions and usual pathways of care. Whilst the use of telehealth services was projected to increase in other countries, in Australia prior to COVID-19 less than 0.1% of Medicare Benefits Scheme (MBS) consultations were via teleconsultation. Any potential solution will need to see a shift in funding models and virtual care healthcare service incentivized. The solutions must incorporate safety and quality, standards of care, patient engagement, continuity of care, privacy and security.

7. Conclusion

Virtual care should be considered as a supplement to face-to-face and telehealth services. It will provide additional choice for patients about when, where and how they seek healthcare that suits their needs. We need to move from the theoretical construction of what virtual care can provide to the reality of creating a healthcare system that implements and supports virtual care. Currently, there is no framework for how to move forward with virtual care in a comprehensive manner in Australia [20, 27]. Without an inclusive and all-encompassing framework for understanding what virtual care is, the facets it comprises, its challenges and what benefits it can realize, it is not possible to innovate and devise solutions that meet the changing and competing demands in Australian healthcare including measures to address digital divide which must be addressed as part of regional economic and social development strategy [28]. This becomes a powerful driver for investigating the strategic, tactical and operational necessities to further patient-centred and integrated care which will reduce financial burden for our healthcare system by tackling common pain-points such as minimizing length of stay and last-minute cancellation [29]. Despite the barriers, the drivers for exploring solutions using virtual care outweigh the perceived difficulties. Virtual care is not anticipated to replace traditional models of care, but rather to enhance them and there is a need to substantially integrate virtual care into routine care practices in Australia.

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MindTick: Case Study of a Digital System for Mental Health Clinicians to Monitor and Support Patients Outside Clinics

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Abstract. The current COVID-19 pandemic has highlighted the limitations of relying solely on in-person contact for diagnosis, monitoring and treatment of mental health conditions. Mobile health approaches can be used to monitor mental health patients remotely, but they are not properly integrated with existing models of healthcare service delivery. We present findings from a case study of a mobile app enabled cloud-based software program rolled out in a phone based psychological service to enable real-time/temporal monitoring. The program offered patients an app to record measures of symptoms in everyday contexts and provided clinicians with access to an accompanying dashboard to use information from the app to tailor treatments and monitor progress and ultimately facilitate earlier and personalised care decisions. Feedback related to implementation and utility was gathered from clinicians through a focus group conducted two months post-roll-out. Findings identified that the system is valuable and feasible, however implementation issues were identified. These are discussed in order to inform future work in this area to support the delivery of timely and responsive mental health care in the community.

Keywords. Mental health, real-time monitoring, implementation

1. Introduction

The COVID-19 pandemic has led to social isolation, restricted movement and disruption to traditional health services throughout the community. Although these stressors affect everyone, it is people with existing mental illnesses who are likely to suffer disproportionately due to higher levels of social disadvantage and poorer underlying physical health [1]. Mental health clinicians cannot offer routine clinics or home visits to conduct mental health assessments during pandemic-like situations. With limited monitoring, these deteriorating patients will go undetected and relapse can occur, substantially contributing to mental health care costs through utilisation of emergency services and psychiatric hospitalisations [1]. The need for sensitive monitoring that can be deployed during pandemic-like situations is therefore necessary for both health and economic reasons.

Monitoring is integral to adequately manage mental illnesses. Routine outcome monitoring to measure change and improve clinical practice is a mandated policy in the

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public mental health services of all states following the National Mental Health Plan agreed between Australian and State Governments in 2002 [2]. In current practice, symptoms and functioning of registered patients are monitored at fixed-time intervals by clinicians using a set of standardised instruments that rely on patient report of past experiences or expert observations in controlled settings [3]. These approaches yield only a periodic "snapshot" rather than a time-varying record of a person's symptoms, behaviour and functioning that is necessary to detect emerging decline early. The ability to administer these forms of assessment is further diminished in the aftermath of extreme health events such as the pandemic, as these assessments are typically conducted in person and at treatment facilities that may no longer be feasible *e.g.* due to social distancing requirements or other circumstances. Furthermore, it has been demonstrated that self-report instruments, even if validated measures, are subject to recall bias, function overestimation, social desirability effects and state-dependent biases [4]. Expert observations made in a controlled clinic setting are also not reflective of how patients function and experience symptoms in their home during daily life/the real world. Both approaches lack the temporal resolution necessary to detect subtle changes in a patient's status [5]. Consequently, the benefits of outcome monitoring at fixed time points are in doubt, as affirmed by a Cochrane meta-analysis [6].

The pandemic has highlighted mental health care providers have a pressing need for alternative ways to monitor and support patients digitally and remotely [7]. Changes in activity, sleep, mood, social interaction and medication adherence are early warning signs that often precede relapse in people with severe mental illness. These changes can now be identified from evidence-based monitoring technologies [8]. Growing literature in mental health suggests that mobile phones can be used to monitor time-sensitive mental health changes in real-time and remotely [9]. This can be easily achieved through repeated passive and active data collection via a mobile phone application (app). Passive approaches utilise automatically-captured sensor signals in the devices, which are associated with individuals' daily behaviours [10]. For example, the temporal patterns in location and movement sensor measures have been shown to predict changes in mood symptoms and functioning levels [11]. Patients can also actively report symptoms on their mobile phone application in real time, close to experiences, which overcomes recall bias and captures intra-subject variability [4].

The feasibility and validity of mobile device data collection has been demonstrated in individuals with depression [12], bipolar [13] and schizophrenic disorders [14]. Work led by our team shows clinician support for using technology to monitor patient progress and risk in real time, provided it is well integrated into clinical practice [15]. Continuously monitoring a patient's experience of symptoms and behaviour closer in time to real-life events can capture warning signs of suicidal ideation weeks in advance [16], or phase change onset in bipolar disorder [17,18]. Evidence from randomised controlled trials (RCTs) shows the use of real-time monitoring measures to guide management improves patients' symptom outcomes and reduces hospitalisations [19,20].

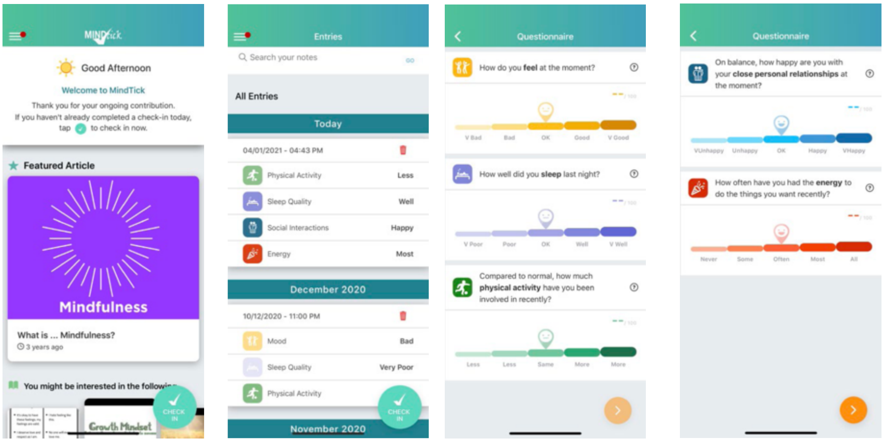
Despite the evidence for the effectiveness and feasibility of continuous, real-time monitoring of mental health symptoms to inform care, such a model of care is yet to be utilised in traditional health service settings. To address this gap, we have developed an app-based monitoring system (MindTick) specifically designed to make data available to mental health clinicians in a real-world clinical service.

2. Description of MindTick

The MindTick system gathers real time functional and symptomatic measures from patients through apps installed on their mobile phones which can be charted over time on an online dashboard viewable by clinicians. As a cloud-based solution, MindTick is designed to be delivered at scale with the ability to be tailored to support the delivery of services addressing various health conditions. The MindTick system comprises the following components.

2.1. Monitoring app for patients

The app extracts passive data from the phone's on-board sensors and applies analytical algorithms to convert these signals into time-stamped measurements of behaviours (e.g., sleep, activity, mobility, social interactions). Through eight validated questions, it actively prompts users at random and weekly intervals to report subjective momentary experiences on symptoms (mood, sleep, alcohol cravings, appetite) and functioning (work, social, family) [21] (Figure 1).



Good Afternoon

Welcome to MindTick

Thank you for your ongoing contribution.
If you haven't already completed a check-in today, tap ✓ to check in now.

Featured Article

What is ... Mindfulness?
3 years ago

You might be interested in the following

All Entries

Today

04/01/2021 - 04:43 PM
Physical Activity: Less
Sleep Quality: Well
Social Interactions: Happy
Energy: Most

December 2020

10/12/2020 - 11:00 PM
Mood: Bad
Sleep Quality: Very Poor
Physical Activity

November 2020

How do you **feel** at the moment?

How well did you **sleep** last night?

Compared to normal, how much **physical activity** have you been involved in recently?

On balance, how happy are you with your **close personal relationships** at the moment?

How often have you had the **energy** to do the things you want recently?

Figure 1. Screen shots of patient app

2.2. Feedback dashboard for clinicians

A web-based clinician dashboard accompanies the app and allows both patients and clinicians to access the data and visualise it (Figure 2). It presents each monitored variable online graphs, making interdependencies and time patterns visible. Once registered, clinicians can log in at any time and view their patients' latest dashboards.

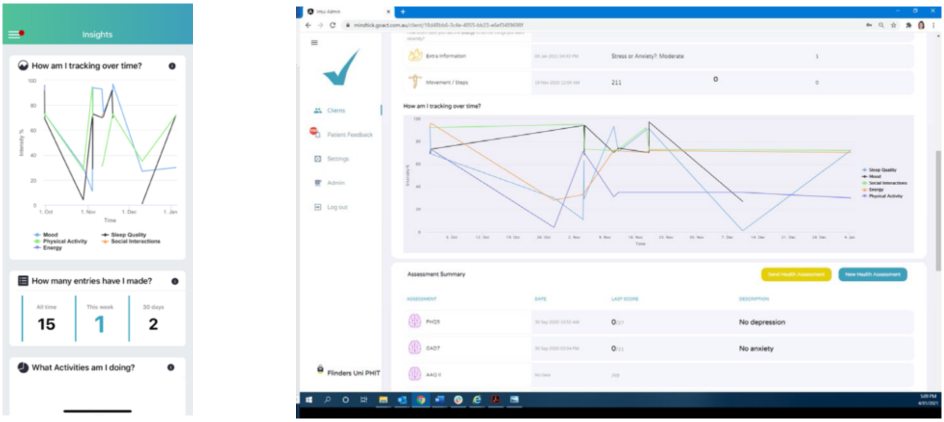


Figure 2. Screen shots of data visualisations in the patient app and clinician dashboard

Integrated security and privacy features in the app and dashboard, already reviewed and approved by two ethics committees in previous research, ensure that sensitive data is securely collected, stored and shared, and complies with the Australian Privacy Act 1988.

In order to understand potential benefits and barriers to adoption of such a system within mental health services within Australia, we present a case study describing the roll-out of MindTick with a real-world phone-psychotherapy clinic and report the learnings gained from a focus group conducted with clinicians who used the system to explore issues associated with implementation processes, utility and acceptability.

3. Case Study Methodology

3.1. Description of the service where MindTick was implemented

The roll-out site was the Improving Access to Psychological Therapies (IAPT) service based at the Flinders Medical Centre (FMC) in Adelaide, South Australia. The IAPT service offers phone-based ‘low intensity’ psychological therapies to individuals aged over 18 years who present to FMC ED in psychological distress. Exclusion criteria for IAPT intervention includes those who are actively suicidal, psychotic, taking benzodiazepine over 10mg diazepam (or equivalent) daily, alcohol dependency, heavy illicit drug use, homelessness, under the age of 18 years and under the care of Community Mental Health Team and those already receiving psychological therapy. The IAPT service comprises four therapists who provide a service to around 150 patients per year.

Referred patients have an initial face-to-face assessment and receive weekly telephone sessions and bibliotherapy with guided self-help led by a brief intervention therapist for 6-7 sessions. This evidence-based brief Cognitive Behaviour Theory is considered a pragmatic, efficient, and cost-effective intervention delivery, especially for low intensity mental health issues.

3.2. Implementation process

Prior to commencement of the trial, an information session was held on site with IAPT clinicians to discuss the implementation of MindTick and how the platform could be integrated into daily workflow with minimal clinician burden.

Clinicians were the first point of contact with potential participants and deemed whether they would be suitable to trial MindTick. Participants were required to be accepted for treatment at IAPT for a mental illness as defined in the DSM-5 or ICD-10 and own an android or iOS compatible smartphone. There was no exclusion on gender or ethnicity, however, patients with insufficient ability to understand the study instructions, or with a documented cognitive impairment, substance abuse, or hazardous use of alcohol were excluded. Additionally, patients judged as not able to participate by their treating clinician (based on their assessment that participation would present risks to the patient) were also excluded.

Clinicians were briefed on how to introduce MindTick during the session, and details of suitable and interested patients were passed to a recruiter based at the clinic. The recruiter contacted the patient and guided them through consent and enrolment. Implementation of MindTick was approved by the Southern Adelaide Clinical Human Research Ethics Committee (SAC HREC EC00188): HREC/18/SAC/168.

Prior to each treatment session, IAPT clinicians viewed the dashboard to ask patients more nuanced questions about insights over the period between appointments, and they would record these insights in their clinical information system. The roll-out was undertaken between July and September 2019.

3.3. Exit interviews with IAPT clinicians

Following the roll-out of the MindTick system, four clinicians participated in a focus group in December 2019. Focus group sessions were conducted by second and third authors to a) explore how MindTick was used by clinicians and the value and impact it had, b) how MindTick was introduced to patients, c) barriers and enablers of use, and d) open discussion re: recommendations. Sessions were audio-recorded and transcribed verbatim. Transcripts were analysed in NVivo (QSR International Pty Ltd. NVivo (version 10), 2012) by second author using thematic analysis techniques described by Braun and Clarke [22] to identify recurring patterns relevant to understanding clinician's experiences of using the MindTick system. First and last author then defined the final themes to illustrate the key learnings from the focus group discussion.

As indicators of clinical severity of enrolled patients, measurement values of assessments administered at the commencement of routine practice were also recorded (Patient Health Questionnaire scale (PHQ9) [23], General Anxiety Disorder 7-item (GAD-7) [24] and Work and Social Adjustment Scale (WSAS) [25]).

4. Results

4.1. Overview

Four clinicians were signed up to use the MindTick system in their practice. They introduced the app to 18 patients between July and September 2019. Five patients installed the app (female n = 4, age = 26.6 (SD = 8.8) years). Baseline scores for PHQ-

9, GAD-7 and WSAS were 18.20 (SD = 8.47), 12.40 (SD = 6.23), 28.20 (SD = 8.90), respectively, indicating the presence of depression, anxiety and moderately severe work and social functional impairment. Of a possible 6 sessions, the average attendance rate was 3.40 (SD = 2.41).

4.2. Experiences of clinicians

Four main themes relating to incorporating MindTick into mental health service delivery emerged from the focus group discussion with clinicians. These are presented below along with supporting quotes.

4.3. Implementation process issues

a) Barriers

Clinicians reported that patient recruitment was the most difficult aspect of implementation. The majority of patients were extremely overwhelmed or distressed at their first appointment with the mental health service and were reluctant to consider using the MindTick system at that time*: "There's a lot going on for people when they're initially referred... people might just say "yes" to get a service, not necessarily to participate in the research." "Offering it right off the bat when people first come in and are really distressed may not be the best time."*

Clinicians found it difficult to remember to integrate the MindTick system into practice, especially during the first session with patients*, "I found it hard to embed…keep at the forefront of my mind as there is a lot to cover in the initial assessment."*

b) Enablers

Once clients were using the system, mental health clinicians reported very positive experiences regarding implementation processes, *"Once they (clients) are signed up…it is fairly streamlined…behaviour we can just maintain. That's not anything we would find difficult." "It (the dashboard) put into context what she (client) was telling me, and so did the feedback report."*

4.4. Utility of Data

Clinicians highlighted several examples where the data collected and presented by the MindTick system was useful (especially visual representation i.e. line graphs); *"She (client) was able to see that because she was physically unwell at the time, that her physical symptoms were impacting on sleep and how that was impacting on her anxiety." "I think when they (clients) have something that's a visual…correlation between maybe say sleep and mood... having that visual is a good way for people to actually make most correlations." "One client went through all six sessions and liked the app a lot – used the reports. This was useful because there was a space of a fortnight between sessions…she was feeling good at the session time and many of the stressors had been forgotten. She was able to reflect on that fortnight using the reports as her measures went up and down." "It was making him more aware of his mood and its relationship to sleep and levels of activity…doing what your app is designed to do."*

The MindTick system integrated well into the IAPT service, with clinicians reporting that the dashboard data informed the triaging and discharging of patients;

"We had a client who had disengaged from treatment, but she was still entering on the MindTick app. It showed that her mood was actually declining so that did influence us in what we did in our discharge process to advise the GP that she was possibly in need of support and we asked the GP to book an appointment with her"

Clinicians also found that the reports produced by the MindTick system were easy to interpret and the data helped to inform practice, *"It verified what my impression was of the client in terms of her progress and in terms of her response to her stressors. I think that was the most useful aspect of it."*

4.5. Environmental context

At the time of the trial, the IAPT service was experiencing decreased referrals due to the COVID-19 pandemic*; "Don't think it is the time to continue this with the current pandemic, think we could reassess down the track." "At that time there were… quite a lot of DNA (did not attend), people who didn't end up attending the assessment."*

In addition, the majority of clients were highly distressed and perhaps not appropriate*, "These people present to ED and are referred to IAPT within a week so these are very distressed people with incredibly complex issues". "The majority didn't see that they could actually then manage an app as well as the workbook." "...when there are so many other issues going on e.g. suicidal ideation etc participating in a research project may not be top priority."*

4.6. Recommendations

The clinicians made a number of suggestions regarding processes and design to improve the adoption of MindTick*, "As a value-add, maybe sending a text message as an appointment reminder via the app." "There could be some sort of motivational push to keep them (client) engaged." "...start it at session 3 and then get your data that way, when the initial distress is lower."*

5. Discussion

We have presented findings from the roll-out of MindTick within a routine public mental health service. The MindTick system gathers real-time functional and symptomatic measures from patients through apps installed on their mobile phones and charts these measures over time on an online dashboard viewed by clinicians. Clinicians working in the service provided feedback on the roll-out experience in a focus group discussion and identified barriers and enablers to implementation that will be useful to inform future work.

Clinicians reported the main barriers to implementation were related to patient recruitment and "embedding" new processes into their practice. The challenges associated with recruiting mental health patients into research trials are well recognised [26] and can be compounded by poor motivation levels typical of illnesses such as depression and schizophrenia [27]. In our case study, patients were recruited from the emergency department of a large metropolitan tertiary hospital and were extremely distressed. Future work should evaluate the suitability of this target group and consider recruiting less complex, less acute patients.

Challenges around "embedding" MindTick processes into practice relate to adoption as defined in the RE-AIM framework ie. the absolute number, proportion, and representativeness of settings and staff who are willing to offer a program [28]. Strategies to improve adoption include highlighting the program's ability to attract people to use the service and identifying existing resources and practices that would make it easy to deliver the program, including assessing clinicians' level of expertise to do so. It is debatable as to whether the mental health clinicians' current working paradigm allows the incorporation of the detailed patient information provided by the MindTick system into their treatment responses. This is a phenomenon explored by Feijt et al [29] who developed the Levels of Adoption of eMental Health model to provide a structured representation of factors affecting the uptake of eMental health practices by clinicians. Future work should explore this further to ensure both clinicians and patients benefit from eMental health services.

If recruitment barriers were overcome, clinicians reported that the MindTick system was very easy to use. They also reported good clinical utility of the data presented in the clinician dashboard. The data provided context and nuance to patient-reported symptoms and helped to inform practice and discharge processes. Documenting and disseminating these positive experiences to colleagues will also help to enhance adoption [30].

The environmental context aspects affecting the delivery of the trial as reported by clinicians were due to factors intrinsic and extrinsic to the service. Intrinsically, clientele have a tendency to not attend appointments and are also extremely distressed at their initial appointment. Extrinsically, the roll-out occurred during the COVID-19 pandemic at a time when the service was under considerable additional pressure. These factors contributed to the low numbers of participants which must be considered as a limitation of this case study.

The recommendations made by clinicians regarding future delivery of MindTick are very valuable as they have an intimate understanding of clinic processes and their clientele. Similar suggestions were also made following our work developing a digital recruitment strategy in the mental health research setting [31]. These recommendations emphasise that careful consideration must be given to future recruitment processes. The additional features suggested by clinicians e.g. reminders for appointments, homework etc should be considered as they are also likely to improve adoption of the system by clinicians and adherence by patients.

6. Conclusion

Mental health services assess patients at fixed intervals and rely very much on patient memory, which is less accurate, prone to biases and not suited to detect early warning signs. Facilitating clinicians to continuously collect and review patients' symptom and functional measurements will enable early identification of relapse indicative symptoms, and hence earlier treatment, which, in turn, may improve level of functioning and quality of life. By addressing implementation barriers identified in this case study, MindTick has the potential to enhance clinicians' capacity to recognise change in symptoms and functioning in near real time and improve care management for people with mental illnesses.

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Is There an App for That? A Scoping Review of Apps for Care Workers in the Aged Care Sector

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Abstract. Objective: To identify and review phone applications (apps) that could be used by care workers to help them plan and provide palliative care in the aged and community care setting. **Methods:** A scoping review. Searches were conducted in App Store and Google Play to identify apps relevant to care workers in the context of palliative and end of life care provision. Relevant apps were downloaded and evaluated. Apps allowing full access were additionally ranked against the Mobile Application Rating Scale (MARS). Information relating to the app as listed in the app stores were also extracted. **Results:** Of the 1,168 identified apps, only eight could be shortlisted for inclusion. The included apps were mostly English language and developed in high-income countries. The apps were primarily aimed at information provision, with limited content on palliative and end of life care. It was unclear if any of the apps were underpinned by evidence or theoretical frameworks, and none disclosed information on the app development process including involvement of end-users. The mean MARS score for full-access apps was 3.94, with the app iNotice for Carers scoring the highest score of 4.1. **Conclusion:** Currently available care worker apps appear to have limited functionality and scope in relation to palliative and end of life care. There is opportunity for a co-designed care-worker app development endeavour that is underpinned by robust evidence, and has high-level usability and relevance.

Keywords. Care worker, apps, mhealth, palliative care, end of life care.

1. Introduction

1.1. Aging Population

The global population is aging rapidly. It is estimated that over 16% of the world's population will be aged over 65 by 2050 [1]. A similar trend is observed in Australia, with over 15% of Australians aged 65 years or over [2]. While Australians are living longer, their later years are often impacted by chronic life limiting conditions such as cardiovascular diseases, cancer, and neurological conditions [2]. Globally, 23% of the total global burden of diseases is attributed to older people [3], making them a significant consumer of health, aged and disability care services [2]. While the healthcare sector provides much needed clinical and complex care to older people on an as needed basis, the aged care sector caters for ongoing personal and clinical care needs of many older people.

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In Australia, 1.2 million older people receive aged care services either in their homes or in Residential Aged Care Facilities (RACF). To support the continued independence of over 95% of older Australians living in the community, the Australian Federal Government offers a number of programs [2]. Under these programs, almost a million older people receive personal and clinical care in their homes [4]. With growing numbers of older people with complex co-morbidities continuing to receive aged care services, the aged care workforce is increasingly being expected to cater for the End of Life (EOL) and palliative care needs of their clients. Palliative care is defined as person and family-centred care provided to those with chronic life limiting conditions with little to no prospect of cure, where the aim is to optimise quality of life [5].

More than 366,000 people work across the Australian aged care sector, two thirds of whom are involved in direct care provision [6]. Direct care in the aged care sector is generally provided by the occupational group known as 'care workers' [7]. Care workers spend the largest amount of time directly interacting with residents/clients, while providing personal care activities such as showering, toileting, and helping with meals [8]. These care giving interactions could provide an opportunity for the identification and provision of care that is in line with the palliative approach to care. It should be noted that while planning and provisioning for a comprehensive palliative care plan is not within a care worker's scope of practice, a broader understanding of palliative care could allow them to identify consumer's palliative and EOL care needs; and report these needs to relevant clinical managers (such as senior registered nurses) for further action.

However, with barely 7% of care workers in Australia receiving any kind of palliative care education [7], much needs to be done in enabling them to support clients and residents with palliative care and EOL needs. Technology and innovation can be viewed as important means of enhancing the capacity of the aged care workforce and smartphone apps are one example of emerging technology solutions.

1.2. Apps

Significant advances in smartphone technology and a proliferation of app development has occurred since the release of the first Apple iPhone in 2007 [9]. An app is a self-contained piece of software, developed for use on mobile devices and made available through app stores [10]. Health related apps make up a significant proportion of available apps. Currently there are over 45,000 healthcare apps available in the Apple App Store alone [11]. Although exercise and wellness apps comprise the majority of such apps, a growing number of apps are available to assist professional care providers at the point of care [12]. There are numerous apps for professional care providers offering assistance with tasks such as drug dose calculations [13], chronic disease management, health risk assessment [14], and access to guidelines [15]. While apps for professional care providers are growing, apps specific to the palliative care workforce also seem to be growing, albeit slowly. A recent systematic review of clinician focused palliative care apps reported 46 apps, many of which were not underpinned by any evidence base [16]. While this review included any palliative care apps targeted at clinicians, the results were not specific to the aged care setting and to care workers. To date, little is known about apps that could be used by care workers in relation to palliative care provision in the aged care setting.

The aim of this study was to identify and review apps that could be used by care workers to help them recognise, report and provide palliative care in the aged and community care settings.

2. Methods

This review adhered to the following five stages: (1) problem identification, (2) literature search, (3) data evaluation, (4) data analysis, and (5) presentation [17]. The reporting of this review adheres to the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) statement [18].

The intent was to identify apps that could be used by care workers to help facilitate palliative care practices in the aged and community care settings. Apps were included if they were:

- Intended for use by careworkers
- Intended for use by family carers
- Designed for use by those involved in providing palliative care
- Available for downloading through the major app stores

Apps intended for health professionals working in general aged care were excluded.

Searches were conducted on 18/11/2019 on two leading mobile operating systems which make up 99% of the global smartphone market [19] (Apple iTunes© for Apple and Google Play™ for Android) using keywords: personal care attendants, careworker, care workers, palliative care support worker, hospice, home palliative care, assistants in nursing, and support worker palliative care. Using the two main app stores enabled us to have a controlled dataset of publicly available apps.

Using the 'copy and paste' function, the following details relating to all of the resulting apps were exported into an MS Excel Spreadsheet: app name, developer's name, price of the app. The next step was de-duplication, and insertion of hyperlinks related to each app in the relevant App stores. Once all the Apps were captured and relevant information was constructed linking the apps to a URL, each app was manually reviewed according to the study protocol. Resulting apps were screened based on their name and description as noted in the App store. The screening and selection of apps was carried out by one author (LPL), and overlooked by another (JT). Any instance of disagreement was planned (apriori) to be resolved via discussion with the third author (PV).

Only those apps that were relevant to care workers or palliative care support workers in the context of aged care were selected for full review and data extraction. Apps meeting the eligibility criteria were downloaded for detailed evaluation and assessment. As this review aimed to explore the full scope of apps available, apps with restricted access (such as institution or region limited apps) were anticipated. Therefore, data extraction of eligible apps that offered limited access was agreed to be carried out based on the app description provided by the developer. Eligible apps that allowed unlimited access were reviewed extensively by exploring every tab/function they offered. Data relating to the features and the content of included apps was extracted and placed in a data extraction table. Apps that allowed full access were evaluated and rated against the Mobile App Rating Scale (MARS) [20]. NVivo 12 Pro was used to analyse the 'information', 'category', 'language', 'availability of App' and 'intended user' fields.

2.1. The MARS tool

The MARS is a reliable and objective tool used for assessing the quality of mobile health apps with excellent internal consistency ($\alpha = 0.92$) and interrater reliability (ICC = 0.85) [20]. It includes 23 items across the following three sections: classification, app quality and satisfaction. Each item is rated using a 5-point scale that ranges from 1 = Inadequate, to 5 = Excellent. The classification section of MARS covers descriptive information such as affiliations, target population and some technical aspects of the app. The quality section includes 19 items and allows evaluation and rating of an app's engagement, functionality, aesthetics, and information quality. The four-item subjective quality section focuses on user satisfaction. The overall MARS score for an app is obtained by calculating the mean scores of the app quality subscales and the total mean score.

3. Results

Of the total 1,168 apps identified from both app platforms, only eight met the inclusion criteria (Figure 1). Five apps (n = 5) were exclusive to the Android platform, one (n = 1) was exclusive to Apple (iOS), and the rest (n = 2) were multiplatform.

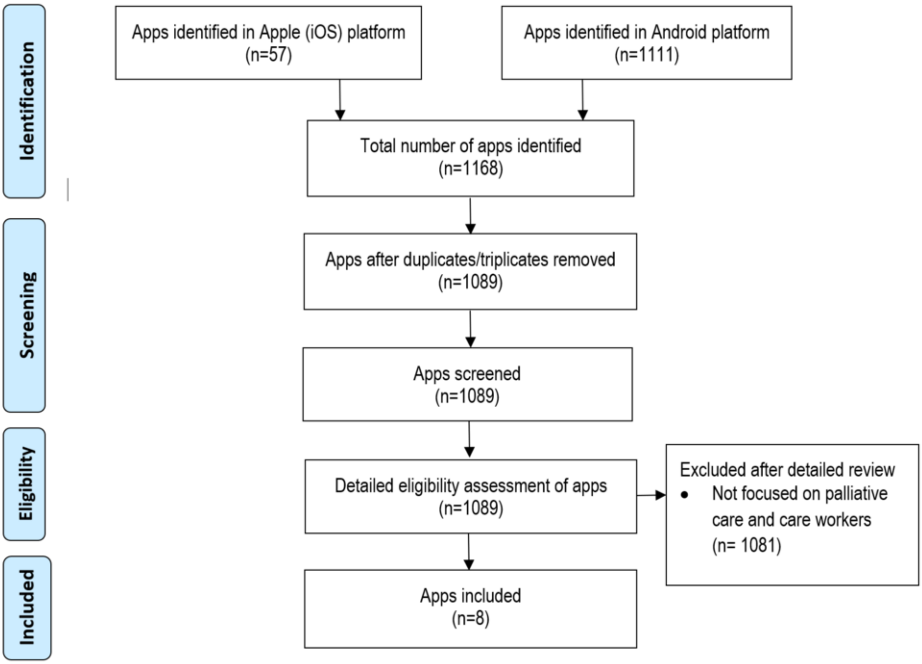

Figure 1. PRISMA flow chart

3.1. App Characteristics

The summary of included apps is provided in Table 1. A majority of the apps (n = 7) were developed in high income countries: two in Australia (iNotice for carers, Palliative Care ACT), two in the United Kingdom (UK) (Keys to Care, The Domiciliary Care Worker), one in Ireland (Understand me), one in Germany (Palliative Care), and one in Spain (mPalliative Care App). One app was developed in India, a low-middle-income country (Caregiver). Only one app offered multilanguage (English or Welsh) selection functionality (The Domiciliary Care Worker). A majority of the apps (n = 5) were available only in English (iNotice for carers, Palliative Care ACT, Keys to care, Understand me), while one app (Palliative Care) was available only in German. A majority of apps (n = 5) allowed unrestricted access (iNotice for carers, The Domiciliary

Care Worker, Palliative Care ACT, Keys to care, Understand me). Of the three apps that didn't offer unrestricted access, two (n = 2) required unique login credentials to use the app (Caregiver, mPalliative care), while the third (Palliative Care) kept crashing and was not functional.

These apps were developed by various groups/authorities such as: government body (iNotice for carers, The Domiciliary Care Worker, Palliative Care ACT), charity organization (Keys to care), health care organization (Caregiver, Palliative Care), and government & charity partnership (Understand Me). The developer of one app (mPalliative Care) was not identifiable due to restricted access and information provided by the app. In terms of the target audience, half of the apps (n=4) noted that they were targeted at care workers (iNotice, The Domiciliary Care Worker, Understand Me, Keys to care). Two apps (n = 2) were targeted at all kinds of palliative care audiences (patients, family, clinicians and care workers) (Palliative Care ACT, Palliative Care), with the remainder focused on professional caregivers in general (n=1) (Caregivers), and family caregivers (n=1) (mPalliative care).

3.2. Content of the Apps

A majority of apps (n = 6) focused on information or guidance (iNotice for Carers, Keys to care, The Domiciliary Care Worker, Palliative Care ACT, Understand me, Palliative Care). The other two focused on the recording of patient assessment data (Caregiver, mPalliative Care). Only one app (n = 1) provided information and guidance specifically based on care workers' scope of practice (iNotice for Carers). Three apps (n = 3) included prompts or reminder functions in relation to care provision (iNotice for carers, Keys to care, Caregiver). Two apps (n = 2) provided information relating to official guidelines such as Code of Professional Practice for social care (The Domiciliary Care Worker), and person centred intercultural care (Understand me). While four apps (n = 4) included some information on palliative or end of life care (Keys to care, Understand Me, Palliative Care ACT, Palliative Care), information on symptom management and overall care was included in three (n = 3) apps (Keys to Care, iNotice for Carers, Palliative care).

3.3. Critical Appraisal of App Quality

The five apps that allowed unrestricted access (iNotice for Carers, Keys to care, The Domiciliary Care Worker, Palliative Care ACT, Understand me) were evaluated against the MARS [20]. The *app quality mean score* of the five apps was 3.94 (IQR 0.1, range 3.90 - 4.10). All apps were designed for adults. Two apps required internet access for use (Keys to Care, PalliativeCareACT), one of which (Keys to Care) allowed social media based information sharing. In relation to the MARS' four domains of App quality, the iNotice for Carers app had the highest mean engagement score at 2.8, with the rest of the apps scoring 2.0 in this domain. All five apps had the same mean scores in the domains of: functionality (4.7); aesthetics (4.0); and subjective quality (2.5). The iNotice for Carers app had an overall quality mean score of 4.1, slightly higher than the overall app quality mean scores of the rest of the apps (3.9) (Understand me, Keys to care, PalliativeCareACT, The Domiciliary Care Worker).

Table 1. App Characteristics

App Name	Access	Platform	Developer	Cost	Intended user	Focus	Features
iNotice for Carers (Australia)	Unrestricted	iOS & Android	NSW Community Services and Health Industry Training Advisory Body	Free	Care worker and family carers	Information provision	• Designed to assist caregivers in a home environment. • Provides information on a variety of signs and symptoms that may be linked to a person's medication management. • Supports early recognition of indicators and provides relevant prompts. • For care workers there is additional guidance about what action may be taken within their scope of practice. • The ‘iPractice’ feature includes realistic scenarios covering common signs and symptoms; and the appropriate responses.
Keys to care (UK)	Unrestricted	iOS & Android	Relatives and Residents Association	Free	Care worker and family carers	Information provision	• Practical guidance to help improve the health and wellbeing of those being cared for. • Guidance on topics from continence care to emergencies. • Provides reminders of what to think about, ask and do. • Provides news and information, • Offers links and opportunities to share own experience
The Domiciliary Care Worker (UK)	Unrestricted	iOS	Social Care Wales	Free	Care workers	Information provision and guidance	• Describes what is expected of home care workers. • Offers tailored, practical guidance to guide and support care workers in their work. • Builds on the Code of Professional Practice for Social Care.
Understand Me (Ireland)	Unrestricted	Android	Communicate your health Ireland	Free	Health professionals and ancillary staff	Information provision	• Resource to assist health care professionals in caring for patients from diverse ethnic, religious and cultural groups. • Practice guidelines for person centred intercultural care and the provision of interpreter services. • Information on caring for ill and dying patients from culturally and linguistically diverse backgrounds, including palliative care.

Palliative Care ACT (Australia)	Unrestricted	Android	Palliative Care ACT	Free	Anybody with interest in palliative care: patients, family, carers and clinicians		• Enables quick and easy access to information on palliative care when not in front of a computer. • To influence, foster and promote the delivery of quality care at end of life for all and to offer compassion and support to those with a life limiting illness, their carers and families. • Promote palliative care in the community. • Provide education on aspects of palliative care. • Deliver volunteer palliative care services to support clients and their families with care, compassion, respect and dignity. • Advocate for best quality palliative care services.
Caregiver (India)	Restricted	Android	Madhavbaug Clinic	Free	Professional care givers	Communication, care facilitation, medication management	• Allows a caretaker/caregiver to provide compassionate care and personalised eldercare services while the kin or relatives are notified of each healthcare events of their loved ones. • Care worker can create resident profile within the app, add event, alerts, and appointments. • Health data including vital signs, limits for vital signs and prescribed medicines, can also be stored within the app. • App also offers the function to call/chat.
mPalliative Care (Spain)	Restricted	Android	Unknown	Free	Family caregivers		• Patient assessment tools included, likely to be administered by family caregiver.
Palliative care (Germany)	App crashing constantly	Android	Care Impulse	$5.99	Anybody with interest in palliative care: patients, family, carers and clinicians		• German language app. • Information on current studies, therapies, and symptoms. • Provides list of training and events relating to palliative care, hospice care and interdisciplinary cooperation in the German-speaking countries. • Useful tips and tricks for helping palliative care patients.

4. Discussion

Despite identifying over 1,000 apps that may have been relevant to care workers, this review identified only eight apps as having sufficient relevance to careworkers around EOL or palliative care to be included. This highlights a potential issue for careworkers, aged care service providers and others seeking to identify potentially relevant palliative care and EOL mobile resources. The analysis of content also suggests that currently available apps are not particularly relevant and useful for the end of life context and may not recognise the specific scope of practice of careworkers who are not trained as health professionals. Careworkers offer a supportive care role rather than direct health care provision such as symptom assessment, care planning or therapeutic interventions. Currently available care worker apps do not seem to adequately support the EOL caregiving role of the very multicultural care worker workforce, and the multicultural Australian community. Nonetheless, some valuable insights have been generated about the content, quality, and scope of these apps.

While groups having some authority in a health or aged care field produced a number of apps, the app information did not make clear whether the app content was evidence based and current. This is a concerning weakness as it does not assist users to be confident in selecting currently available apps. While there is no gold standard approach to the development of health apps [21], there is a general consensus that the content of a health app should be evidence based, adaptable, useful, and not pose any significant risk to the user [22]. The need for evidence-based content is of paramount importance in the context of care worker apps, where the information provided is likely to be relied upon by end users in planning and delivering care to older and vulnerable clients within a very demanding work environment [7, 8].

Similarly, it was unclear from the review if any of the apps were developed using a co-design approach, where relevant stakeholders (such as: researchers, developers, sector experts, and end-users) are involved throughout the design, development and user-testing stages [23]. Lack of end-user engagement could lead to the development of products that do not meet the needs of the intended users, resulting in app underutilisation or misuse [24, 25]. Involvement of end-users can ensure that the resulting app has high level "usability' and 'ease of use'; both of which are crucial precursors for technology adoption and engagement as per the Technology Acceptance Model [26]. Similarly, involvement of academic and sector experts could help ensure that the content of the app is based on robust evidence, and relevant local and national guidelines [27, 28].

All of the apps were designed for written information provision, with none including any interactive or actionable elements. Provision of large volumes of text-based information via apps that are predominantly used in smartphones with small screens is an area of concern, especially as there is evidence to indicate that users find reading on small screens challenging [29, 30]. Even aside from the potential offered by advanced computing and sensor-based functions [31], interactive and video based content could easily be included to improve functionality and, more importantly, engagement by intended users.

Given that most of the information provided in the apps was geared towards improvement of care workers' understanding of best care practices when needed [32], there appears to be over reliance on a passive information dissemination strategy. Inclusion of audio and/or visual material could lead to relatively greater recall of information [33]. Optimising the learning and recall opportunities in care worker apps is crucial given care workers workload, where they are often required to perform their daily care activities under significant time pressure [7].

It is interesting to note that only a very small number of apps included information on palliative and EOL care. This is an area of growing importance in aged care as care provision will inevitably include care for older people at the end of their life. Given that careworkers are closely involved with care delivery to older people (many of whom could be approaching the end of their life in the residential and home care setting [34, 35], the presence of limited palliative and EOL care information in the currently available apps represents a missed opportunity. Inclusion of evidence-based palliative care information that is within the scope of a care worker's practice could increase the range and value of careworker apps. This could include information on how to respond when a client raises issues about advance care planning or end of life changes, or information on common symptoms and changes experienced by older Australians. Issues on how to manage grief and loss for clients and for themselves may also be valuable.

A notable limitation of the included apps was their lack of diversity. A majority of the apps were English language apps. Only one app offered multi-language functionality (Welsh), and another included some information on intercultural care. Further, the content of most of the apps was shaped by predominantly Western/Eurocentric perspectives of dying and EOL care. Such lack of multi-language functionality and diversity could act as a barrier to the use of potentially effective apps by the Australian aged care workforce, where 30% of care workers are born outside Australia [7]. While it is assumed that (at least) basic English language proficiency is necessary for employment in the Australian aged care sector, some members of the workforce may be more likely to engage with an app in their native language, especially if the content of the app covers sensitive topics such as palliative and EOL care [36]. Acknowledgement of the fact that EOL and palliative care are culturally and philosophically loaded constructs [36], and that this care is provided to a very diverse Australian community by an equally diverse aged care workforce is necessary when developing a good quality care worker app.

The MARS based evaluation of the apps revealed that currently available apps do not have a very high-quality score (3.9-4.1). This is not surprising given that the development of mobile health apps remains largely unregulated. Apps providing general information are not classed as a 'medical device', and are therefore not regulated by authorities such as the Therapeutic Goods Administration (Australia)[37], or the Food and Drug administration (United States)[38]. Such lack of control or regulation has led to an overproduction of health apps without safety and privacy assurances; and where the credibility of the developing team and the quality of the app content are largely unknown. [22].

5. Limitations

Some limitations should be considered when interpreting the results of this review. Firstly, we conducted our search in Australia. Apps that are exclusive to app stores of other countries might have been missed by our search. Secondly, although searches of the two most popular app platforms were conducted (App Store and Google Play), some apps hosted exclusively in websites may have been missed in this review. A review of published literature could also have identified additional apps. Finally, while care was taken to evaluate and rate the apps objectively, we acknowledge that some level of subjectivity/bias may have influenced our rating of the apps.

6. Conclusion

Despite the availability of some care worker apps, this review found these apps to be limited in their functionality and scope. Currently available care worker apps seem to lack relevance, usability and any underpinning evidence. Furthermore, apps that cater to the palliative and EOL care giving activities carried out by care workers within their scope of practice were also found to be limited. The development and evaluation of highly relevant, evidence-based care worker apps that could facilitate the palliative and EOL care giving activities of care workers is needed. Future work in the area of care worker app development should consider a collaboration between industry, aged care experts and end-users , with the ultimate aim of developing robust apps underpinned by evidence and shaped by relevant guidelines.

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Telepathology by Realtime Screen Sharing Between Japan and Federated States of Micronesia: Opportunities and Challenges

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Abstract. We have been conducting pathological diagnosis of routine cases in the Federated States of Micronesia by telepathology since 2018, using realtime screen sharing via the Internet with Japan. The number of cases covered in the last three years was 378, and by specimen type, gynecologic specimens were the most common, followed by oral cavity / ENT, skin, and mammary gland. Thirty four out of 60 oral cavity cases were diagnosed as malignant including suspicious. The turnaround time between submission of the specimen and the report of pathological diagnosis was markedly decreased. For the continuous development of global telepathology, it is necessary not only to build a system but also to recruit or train those who perform it.

Keywords. Telepathology, realtime, service delivery

1. Introduction

The Federated States of Micronesia (FSM) is an island nation located north of the equator in the western south Pacific and consists of four states. A population of approximately 110,000 live centered around the main island of each state. The country faces a medical situation where they have no pathologists and because of this, in the past, pathology specimens were sent off island to the United States for diagnosis. To improve the situation, the authors have for the last three years performed the pathological diagnosis of routine cases using international telepathology connected by the Internet between Hokkaido, Japan and FSM. This paper introduces a summary of this work and provides some examples, followed by a discussion of some contemporary problems of the project.

2. Background

While working at the Hokkaido Cancer Center, the first author (KY) was asked if he would be interested in performing telepathology with someone from overseas. After expressing his interest, KY was introduced to the second author (SV) in FSM. SV is of Fijian nationality and is employed by the Pohnpei State Hospital as a clinical laboratory technician and has experience in preparing pathology specimens. In December 2017, KY traveled to Pohnpei to visit the hospital and pathology laboratory. He learned about the conditions regarding pathology diagnoses and was able to verify the specimen preparation techniques of SV. In February 2018, SV came to Japan and spent one month at the Hokkaido Cancer Center where he received training in the preparation of pathology

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specimens. A few months after this, diagnosis by telepathology was started.

3. Methods

The equipment items central to specimen preparation are as follows:

- Tissue Processor: STP 120 (Thermo Scientific),
- Embedding System: TES 99 MEDITE (MEDIZINTECHNIK),
- Microtome: HM 325 (Microm).

The staining and mounting of coverslip is performed manually: only Hematoxylin & Eosin staining is possible. Macrophotography is performed to the maximum possible extent for specimens requiring cutting. The preparation of small specimens is left to the judgement of the responsible laboratory technician. The request for diagnosis should include the following clinical information:

- submission date,
- patient name, sex, age,
- physician's diagnosis,
- site, specimen type, objective, clinical findings, etc.

Once the glass slides have been prepared, an e-mail is sent from FSM to Japan, setting the time for screen sharing. The microscope used is an Elipse 50i (Nikon) with objective lenses of 2x, 10x and 40x. The microscope image is captured by digital camera BFLY-U323S6C-C (PointGrey) in real time and is projected to the computer screen using Panoptiq^{TM} (ViewsIQ). The personal computer is an HP ProDesk (Intel Core i7-6700, 16GB RAM) using Windows 10 Pro with 32 inch-monitor (1920x1080 resolution).

The diagnosing pathologist in Japan uses a 2016 Apple Mac Book Pro 15-inch and screen sharing is performed with TeamViewer^{TM}. The diagnosis is performed by verbally designating the point of observation to the clinical laboratory technician who is operating the microscope and by requesting the lens magnification of the microscope. Once the diagnosis has been determined, it is entered into a text file on the computer in the FSM. Direct evaluation of the quality of the telepathology is very difficult. The authors actively participate in the Anatomical Pathology External Quality Assessment Programme of the Pacific Pathology Training Centre, New Zealand and strive to ensure the quality of their work.

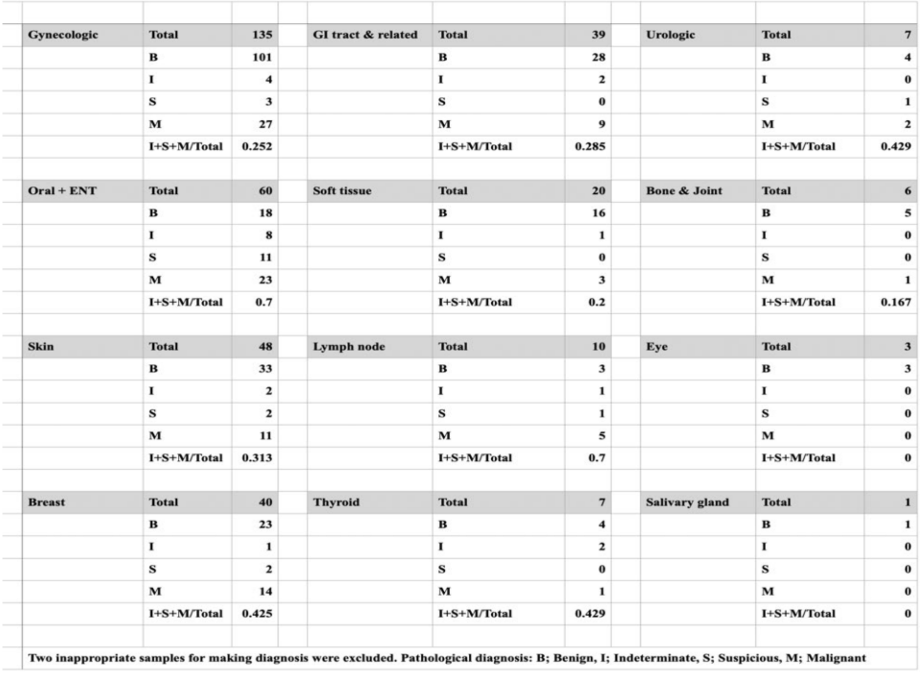
4. Results

As of November 30, 2020, 378 cases have been diagnosed in almost three years (2018: 104 cases, 2019: 162 cases, 2020: 112 cases). This data has been summarized below in Table 1.

Patients ranged in age from 0 to 82 years, with an average age of 45.6 years. There were 124 males and 252 females, while 2 cases were unknown. The organs submitted, starting from the most abundant, are detailed in Table 1 and were as follows:

- gynecologic: 135 cases,
- oral and ENT: 60 cases,
- skin: 48 cases,
- mammary gland: 40 cases,
- gastrointestinal: 39 cases.

Table 1. Number of cases by organ and results of pathological diagnosis



Gynecologic	**Total**	**135**	**GI tract & related**	**Total**	**39**	**Urologic**	**Total**	**7**
	B	**101**		**B**	**28**		**B**	**4**
	I	**4**		**I**	**2**		**I**	**0**
	S	**3**		**S**	**0**		**S**	**1**
	M	**27**		**M**	**9**		**M**	**2**
	I+S+M/Total	**0.252**		**I+S+M/Total**	**0.285**		**I+S+M/Total**	**0.429**
Oral + ENT	**Total**	**60**	**Soft tissue**	**Total**	**20**	**Bone & Joint**	**Total**	**6**
	B	**18**		**B**	**16**		**B**	**5**
	I	**8**		**I**	**1**		**I**	**0**
	S	**11**		**S**	**0**		**S**	**0**
	M	**23**		**M**	**3**		**M**	**1**
	I+S+M/Total	**0.7**		**I+S+M/Total**	**0.2**		**I+S+M/Total**	**0.167**
Skin	**Total**	**48**	**Lymph node**	**Total**	**10**	**Eye**	**Total**	**3**
	B	**33**		**B**	**3**		**B**	**3**
	I	**2**		**I**	**1**		**I**	**0**
	S	**2**		**S**	**1**		**S**	**0**
	M	**11**		**M**	**5**		**M**	**0**
	I+S+M/Total	**0.313**		**I+S+M/Total**	**0.7**		**I+S+M/Total**	**0**
Breast	**Total**	**40**	**Thyroid**	**Total**	**7**	**Salivary gland**	**Total**	**1**
	B	**23**		**B**	**4**		**B**	**1**
	I	**1**		**I**	**2**		**I**	**0**
	S	**2**		**S**	**0**		**S**	**0**
	M	**14**		**M**	**1**		**M**	**0**
	I+S+M/Total	**0.425**		**I+S+M/Total**	**0.429**		**I+S+M/Total**	**0**

Two inappropriate samples for making diagnosis were excluded. Pathological diagnosis: B; Benign, I; Indeterminate, S; Suspicious, M; Malignant

Two cases where the specimen was too small and unsuitable for diagnosis, were excluded. The number of cases determined as malignant (M), suspected malignant (S), indeterminate (I) and benign (B) are also shown in Table 1. For each organ. ‘Indeterminate’ means that it was difficult to judge benign or malignant. Oral and ENT related specimens had the highest percentage of malignant, suspicious and indeterminate diagnoses. Of these, oral specimens of the buccal mucosa, etc. had highest frequency with 39 cases.

As reported by SV, the turnaround time between submission of the specimens and the report of pathological diagnosis was evaluated for the years 2019 and 2020 when glass slide preparation became routine. The turnaround time for cases requested by the Pohnpei State Hospital was four days, for the other states of Kosrae, Yap and Chuck, turnaround time was seven to eight days.

5. Examples

This section highlights some of the more interesting telehealth cases. Example 1 relates to oral cancer in a male in his 40s, a betel nut chewer. Photographs taken at Pohnpei State Hospital with a x10 and x40 objectives are shown in Figure 1 and 2. Screen shots from the monitor displayed through TeamViewer^{TM} in Japan are shown in Figure 3 and 4. The latter two may not be as clear as the display appeared under a microscope. It is well known that oral cancer frequently occurs in betel nut chewers.

Example 2 relates to Hansen’s disease in a male in his 40s. A skin biopsy was performed because of suspected Hansen’s disease, new to the author in 40 years of experience as a pathologist (Figure 5 and 6).

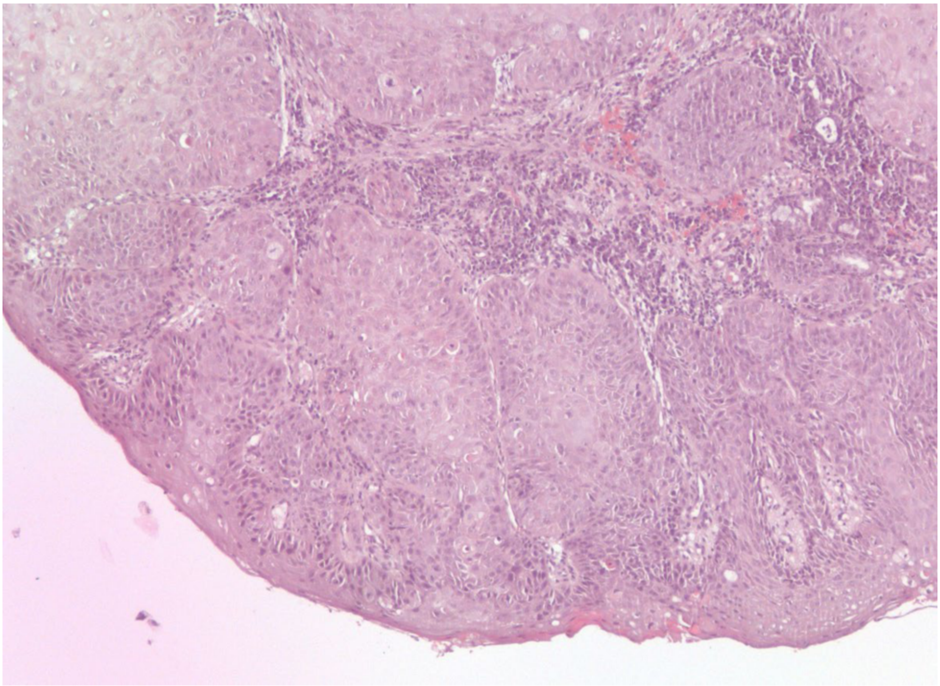


Figure 1. Squamous cell carcinoma, invasive, buccal mucosa. x10. Captured in FSM.

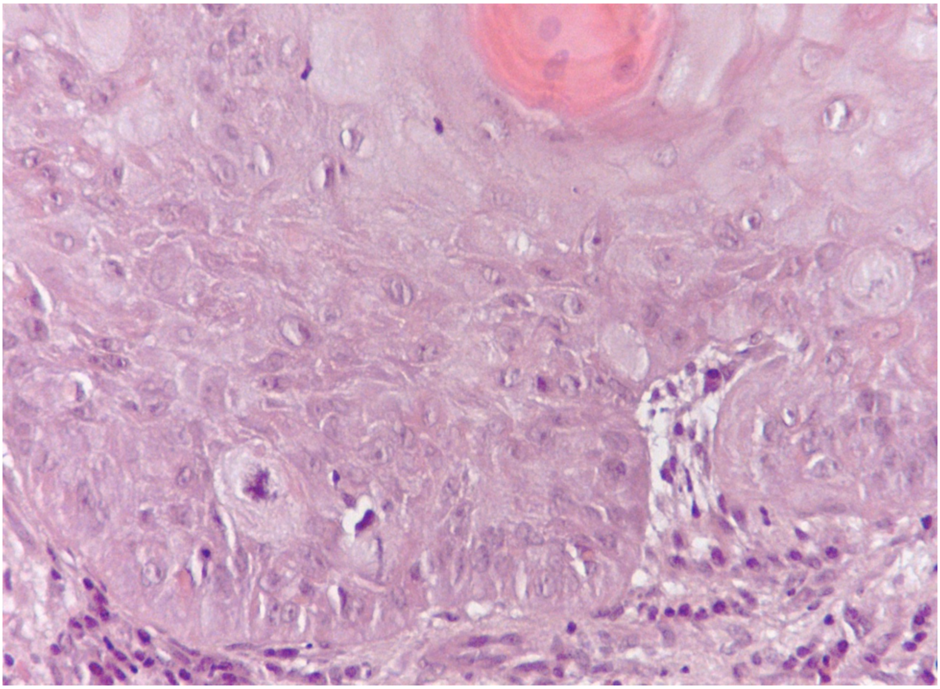


Figure 2. Squamous cell carcinoma, invasive, buccal mucosa. x40. Captured in FSM.

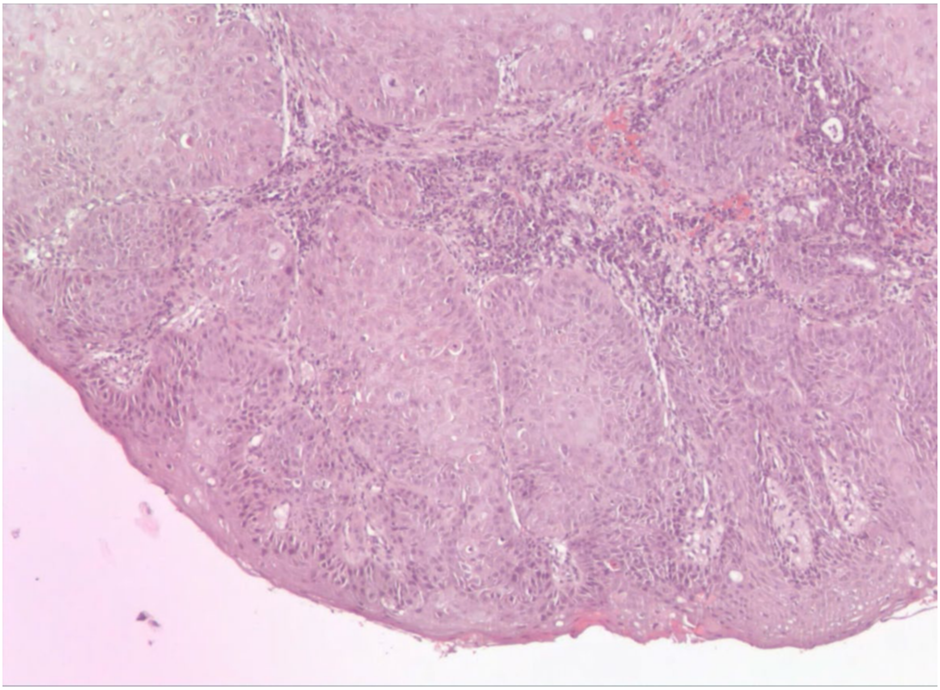


Figure 3. Realtime screen image transmitted by Teamviewer. Captured in Japan. Same image as Fig. 1.

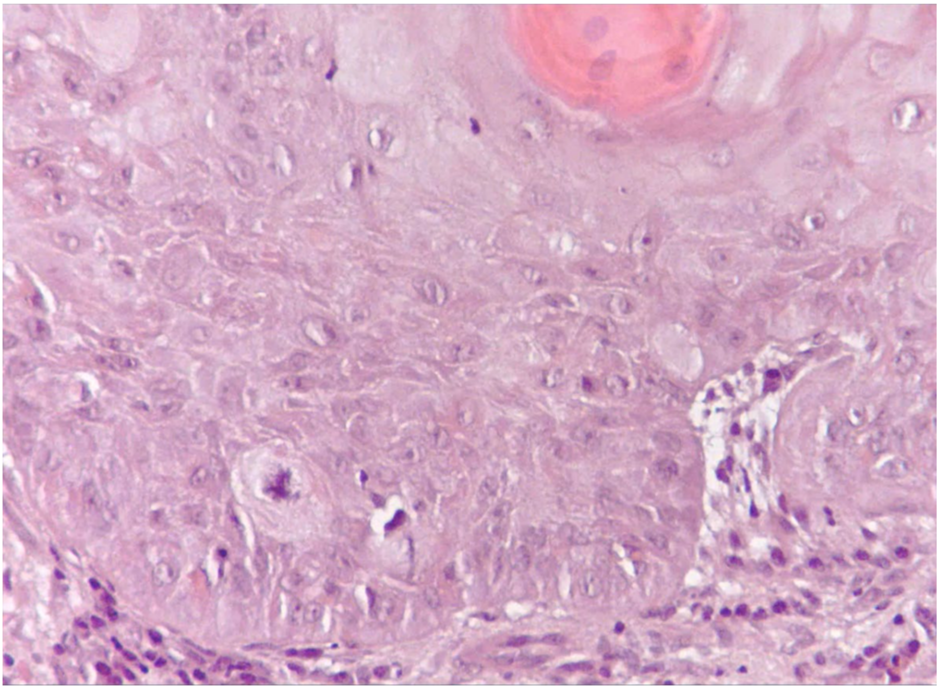


Figure 4. Realtime screen image transmitted by Teamviewer. Captured in Japan. Same image as Fig. 2.

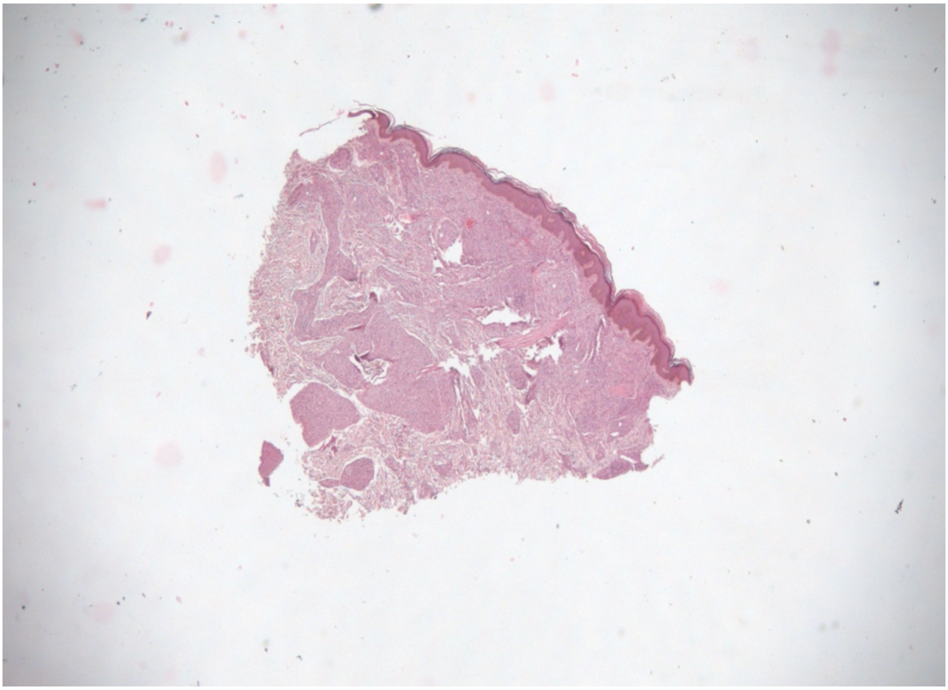


Figure 5. Lepromatous leprosy. Histiocytic aggregation in dermis with irregular margin, looks like cancer cell growth. x2.

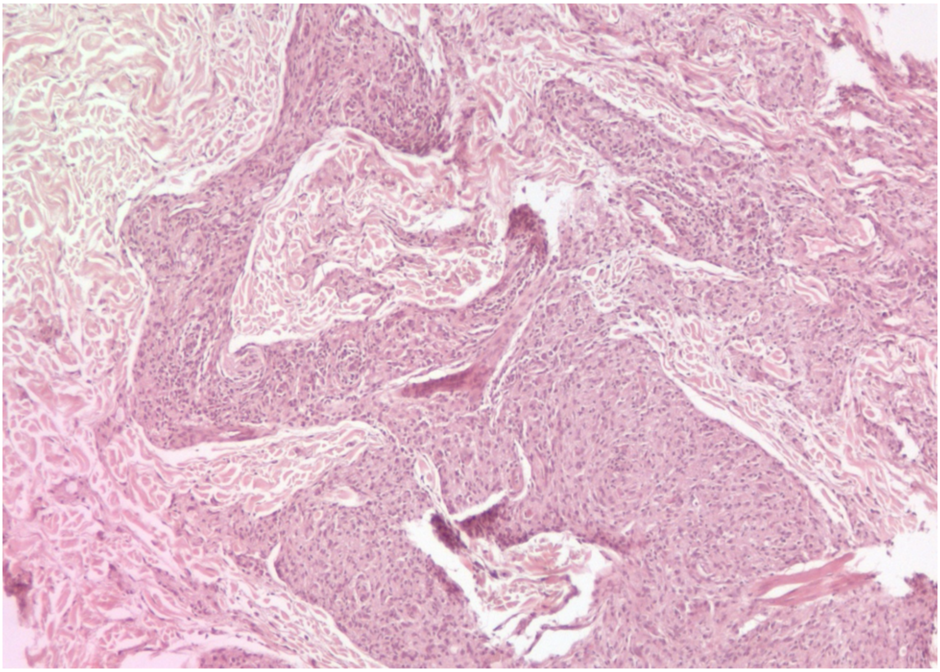


Figure 6. The lesion contains few lymphocytes x10.

6. Discussion

Telepathology began to gain acceptance as a medical technology around 1990 and was one of the first fields to be realized in telemedicine [1]. At that time, it was first used for rapid diagnosis during surgery [2], however its application for the diagnosis of routine paraffin block specimens did not advance, and its spread into the field of cytology was limited [3, 4, 5, 6]. On the other hand, telepathology device development has focused upon whole slide imaging/virtual slide (WSI/VS) and furthermore, the interest of pathologists seems to be moving towards artificial intelligence (AI) aided diagnosis using this system [7, 8]. As the first 20 years of the 21st century is coming to an end, some countries are still unable to receive the benefit of pathological diagnosis and the authors believe that those who have the means to solve that problem should come forward and do so. The FSM is an expansive oceanic federated nation. Consequently, with a vast area and sparse population, it can be imagined there would be difficulties in creating systems that any modern nation should have. The underlying medical system is representative of this. For example, with the exception of nurses, a system of education and training for medical staff has yet to be established in the FSM. They are reliant upon the supply of doctors from other countries. Pharmacists, radiologists, clinical laboratory technicians, etc. are in the same situation. Because of this, constructing a hospital with adequate human resources is challenging.

As an example, consider the treatment of cancer, for which there has been considerable advances in the accumulation of knowledge and organized treatment procedures. In order to perform a certain level of treatment unavailable in FSM requires the patient to be treated at a foreign facility. Without first establishing a diagnosis, the patient cannot be referred to such a facility. If a pathological specimen is sent to a foreign laboratory capable of providing a diagnosis, then a pathological diagnosis can be achieved. If it takes one to two months for the diagnosis, it may be too late for the patient. This type of time lag has previously occurred in the FSM. Telepathology is the tool that can change this situation. WSI/VS has developed well enough to handle this task and is considered a refined system. However, we did not adopt this system because we had no funding for this project. We made no demands upon the governments of the FSM nor Japan to consider this experimental telepathology. The Pohnpei State Hospital has an Internet connection, although it is quite inadequate, and the pathology laboratory microscope has a digital camera connected to a computer connected to the Internet.

We considered using the author’s personal computer and private WIFI connection for telepathology. In fact, we have used the method of real-time screen sharing for telecytology in Japan for over a dozen years [3]. Although financial support was not available at the start, the authors are optimists and continued to establish this telepathology operation between Japan and FSM, with the hopes that the success of the project would attract financial support. There were no time zone problems in the connection between countries or regions for real-time screen sharing because the time difference between Japan and Pohnpei is only two hours. One hour of connection time is possible if telepathology is initiated at 14:00 Japan Standard Time, which will allow the clinical laboratory technician to finish work at the end of a typical workday. Excluding difficult cases, two to three cases with a normal degree of difficulty can be diagnosed in one hour. Real time screen sharing is not without its problems. Operation of the microscope is performed by the clinical laboratory technician of the FSM but because of the first author’s weak English conversation skills, it has been difficult and we had to adapt. Furthermore, the transmitted microscope image compared to looking through the microscope is not as clear. However, this was not such a major concern because of the smooth transmission of the image. The laboratory technician made efforts to prepare clear glass slides after listening to the first author's occasional comments and has become proficient at operating the microscope.

There are a number of other logistical problems. Firstly, the first author is 68 years old and it may be difficult for him to continue this work for another 10 years. It is hoped that another pathologist supportive of these activities would emerge. International support subsidized by governments of multiple nations to create pathologists would be desirable and the author would be glad if this report could be an inspiration for this. Secondly, a current request to perform Pap test cytology has been made by the FSM. It is well known that cytology is the collaborative work of a pathologist and a cytotechnologist. The cytotechnologist is a specialist who not only prepares the glass slide but also performs screening and identification of the neoplastic cell, etc. and requires time and an education system to train them. There are no cytotechnologists in the FSM. In order to make this possible, the recruitment and training of a motivated clinical laboratory technician is necessary. Thirdly, SV is a clinical laboratory technician working from FSM with the first author, but he will, in time, also retire and require a successor. It can be imagined that a person having the knowledge and technical skills to prepare a pathology specimen will be in demand not only in the FSM but in clinical practice in the countries of greater Micronesia and oceanic nations south of the equator. These individual countries need to work together to create a system to train specialized medical technologists. International telepathology is not limited to the construction of a system but fundamentally it also requires a mechanism for local human resources development.

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A.J. Maeder et al. (Eds.)

Subject Index

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A.J. Maeder et al. (Eds.)

Author Index

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