Combating Rehabilitation Service Disruption during COVID-2019 outbreak with Tele-rehabilitation in Hong Kong: An Observational Study

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Abstract

Background: The Hospital Authority is the statutory body providing rehabilitation services to citizens of Hong Kong. With aging population and ever growing service demand, there is huge service gap in ambulatory rehabilitation service. Service bottleneck renders clients not able to receive prompt rehabilitation service and adequate service intensity.For example, around 30% of stroke clients served in HA are below 65 years. The rehabilitation day facility has limited placements; and geriatric day hospital is designed predominately to accommodate clients over 65 and has very few capacities for younger clients. Consequently, a large proportion of younger clients are either discharged without rehabilitation support or occasionally referred to AHOP. In 2013, only 15% and 26% of younger stroke cases received day and outpatient rehabilitation services respectively. The HA began to development tele-rehabilitation service aiming primarily to bridge the service gap. The Tele-rehabilitation (TR) platform is rollout for use to Physiotherapy, Occupational Therapy and Speech Therapy and is receiving positive feedback.

With the outbreak of COVID-19, the three Allied Health professions experience huge service disruption. Service volume decrease remarkably form 50% to 70%. By early February 2020, the TR platform has been used heavily to alleviate the effect of service disruption. The aim of this quick review is to describe the design and development process of TR in HA and the use of this platform to provide rehabilitation service to affected clients during Coronavirus outbreak.

Objective: 1. To describe the design and development process of Tele-rehabilitation system of Hospital Authority
2. The use of TR to improve rehabilitation service to clients in Hong Kong
3. The use of TR to serve clients during COVID-19 and the design of TR system that allows rapid expansion to cater for more clients to be served

Methods: A technology or innovation can only be considered useful if it is accepted and actually used in daily clinical practice. There are several criteria to be considered in predicting whether the users will actually use the technology. The theoretical model of Unified Theory of Acceptance and Use of Technology (UTAUT) is used. The model pointed out the essential domains of: (1) Ease of Use; (2) Perceived Usefulness; (3) Implementation Context; (4) Social Context. The development of the TR platform is taking reference to the different contexts in order to make this product to have satisfactory acceptance and utilization. The whole approach will be user centric and close collaboration with clinical users and clients is maintained in the course of entire project development.

Focus group is formed to work closely with PT, OT and ST colleagues. Detailed discussion and deliberation is conducted to ensure that the therapist find the system useful and easy to use. It is iterated by our users that the TR shall: (1) bridge the service gap in ambulatory rehabilitation service; (2) enable the therapists to prescribe suitable exercise to clients; (3) save time of therapist in view of current heavy workload. It is emphasized that clients shall be able to carry out prescribed rehabilitation activities anywhere, anytime by themselves. TR using off the shelf technology is more favorable because it is easily accessible to clients without need to procure and install sophisticated equipment. After thorough discussion, a new prescription platform (Activity Base Prescribing System, ABPS) together with a mobile app (Rehabilitation App) is to be developed. After therapist performs assessment to client, exercise videos and reminders should be able to be prescribed through a prescription platform and client can access the prescription through the mobile app. The prescription platform shall be easily accessible and aligns well

with existing clinical workflow of therapists. Concerning the mobile app, it shall be user friendly to elderly and able to capture client's performance and sequentially feedback to prescribing therapist.

Results: The ABPS is an integrated prescription platform for different Allied Health profession. The system recognizes professions of logon staff and display relevant content for prescription. Therapist can set various prescription parameter: date, time, frequency, user preferred templates etc. Client's performance is viewable from the platform too. The platform is designed with concept of single platform for multiple clinical conditions. Most importantly, new exercise videos, reminders are able to be added.
The Rehabilitation App is designed to be barrier-free to user. A swipe of push notification sent to clients at designated time will enable client to access training videos. The app is simple, easy to use and all activities prescribe in ABPS will be shown in the App. Altogether 144 training videos are incorporate into the ABPS for therapists' prescription.
Upon the outbreak of COVID-19, the TR system is heavily used. Within a month, 41 new PT videos; 8 ST new videos and later 8 OT videos are added. The utilization from the introduction of the system in Oct 2019 till Jan 2020 is 320 per month. The rate soared to 464 in Feb 2020 and 1989 in March 2020. 31.9% of total ST, OT and PT workforce prescribed TR and the age of clients prescribed with TR is younger. Because other than the elderly clients, more clients are prescribed to use this form of rehabilitation. Moreover, the spectrum of condition prescribed also becomes wider. Very high satisfaction rate is feedback from clients.

Conclusions: Before the outbreak of COVID-2019, TR has been used to bridge service gap for ambulatory rehabilitation service and is receiving positive feedback from therapists in HA since its introduction. After the outbreak, TR has further demonstrated its usefulness in provision of rehabilitation service to a much wider spectrum of clients. TR has become an indispensable tool to therapists, and clients are showing good acceptance to this mode of rehabilitation service delivery. Figures show that only around 32% of ST, OT and PT workforce has used TR. It is believed that there is huge potential for more therapists to use TR in near future and TR will be a new norm in rehabilitation delivery even after the outbreak. The single prescription platform/mobile app for all design facilitates the speedy expansion of video library and enabled the speedy expansion of service. However, further clinical studies are needed to confirm the clinical effectiveness of TR in Hong Kong.
In conclusion, TR in the form of integrated Prescription Platform and Mobile App can be one of the effective means to provide rehabilitation service to clients and has demonstrated its huge potential particularly in the crisis situation of COVID-2019 outbreak.

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Introduction

The Demand and Service Gap of Rehabilitation Service in HK

The Hospital Authority (HA) is the statutory body responsible for managing public health services in Hong Kong. HA provides over 90% of inpatient care, 30% of outpatient care and is the major provider of rehabilitation service to Hong Kong citizens [1]. The Hong Kong Census and Statistics Department projects that the percentage of elderly over 65 will increase from 14.7% in 2014 to 23.3% in 2026 [1]. There is heavy demand for rehabilitation services by this aging population. In 2013, there were respectively around 18,000 and 6,100 acute admissions of stroke and hip fracture cases dealt with by HA [2]. Thirty-eight percent of stroke patients and seventy percent of hip fracture patients were transferred to extended care hospitals for rehabilitation. The average length of stay for extended care to stroke patient was 34.4 days while for hip fracture patient was 23.9 days [3]. Ambulatory rehabilitation service was provided to patients upon discharge from hospitals. The HA commissioned a territory wide Strategic Service Framework (SSF) study on rehabilitation service in 2016 and the report pointed out that there were serious problems of (1) inadequate ambulatory rehabilitation service placement; (2) long waiting time for service; (3) inadequate therapy intensity and frequency to patients in need [4]. The above mentioned inadequacy and service gap of ambulatory service (1) hindered the flow of patients from acute hospital to extended care hospital; (2) delayed discharge of patients from extended hospital; and (3) became a barrier to patients' reintegration into community. In 2018-19, there were over 2.8 million Allied Health outpatient attendances and over 6 million inpatient and day patient attendances [2]. Stroke, cardiovascular diseases, musculoskeletal diseases and trauma and respiratory diseases were the four major groups of patients requiring intensive rehabilitation services.

To overcome the service bottleneck, especially for stroke, fracture hip and frail elderly patients, the report recommended the development of tele-rehabilitation and pursued novel service delivery model of tele-therapy, tele-monitoring and tele-education. The objective was to improve overall access to rehabilitation services. In line with the recommendation, the HA Annual Plan 2019-2020 included the strategic development of mobile solution to facilitate public's access to HA service [3,

4].

Tele-rehabilitation in HA

Tele-rehabilitation (TR) refers to the provision of rehabilitation service at a distance using telecommunication technologies as the service delivery medium. It is an alternative means of providing all aspects of care including interview, physical assessment, diagnosis, intervention, maintenance activities, consultation, education, and training to clients at a remote location [5]. TR has been practiced overseas for many years and there is much research indicating its effectiveness for various kinds of conditions. According to literature, there are a number of benefits, both to patient and family, including: (1) potential saving transportation cost and time; (2) continuity of patient care achieved through provision from a remote location; (3) the ability for patient to practise intervention at convenient times, intensity and sequencing; and (4) the positive effect of rehabilitating in the patient's own social and vocational environment [6]. TR has been practiced by different Allied Health professions since its introduction [7, 8, 9, 10]. Hong Kong has been lagging behind in the development of TR. There are relatively few studies in this field because health care providers have not considered the need for TR in Hong Kong. However, a study of TR in Hong Kong demonstrated the feasibility, efficacy and high level of acceptance to tele-rehabilitation for community-dwelling stroke patients [11].

The Coronavirus Disease 2019 Outbreak

TR development was completed in October 2019. It is aimed to allow therapists to experience TR as a new form of service delivery and forms the basis for future development. Since mid-January 2020, the Coronavirus Disease 2019 (COVID-19) has affected Hong Kong and in late January 2020 the rehabilitation services delivery became seriously disrupted with 50% drop in attendance. To combat the disruption of service, OT, PT and ST extensively utilized the TR platform beginning in mid-February 2020 and the content of the TR expanded rapidly from early March 2020. Since then the use of tele-rehabilitation has increased tremendously. This relatively new mode of rehabilitation service gathered momentum during the Coronavirus Outbreak.

The aims of this study were to:

- Describe the design and development process of TR
- As an observational study, to study how the TR platform was used to overcome the disruption

of rehabilitation service during the COVID-2019 pandemic

Methods

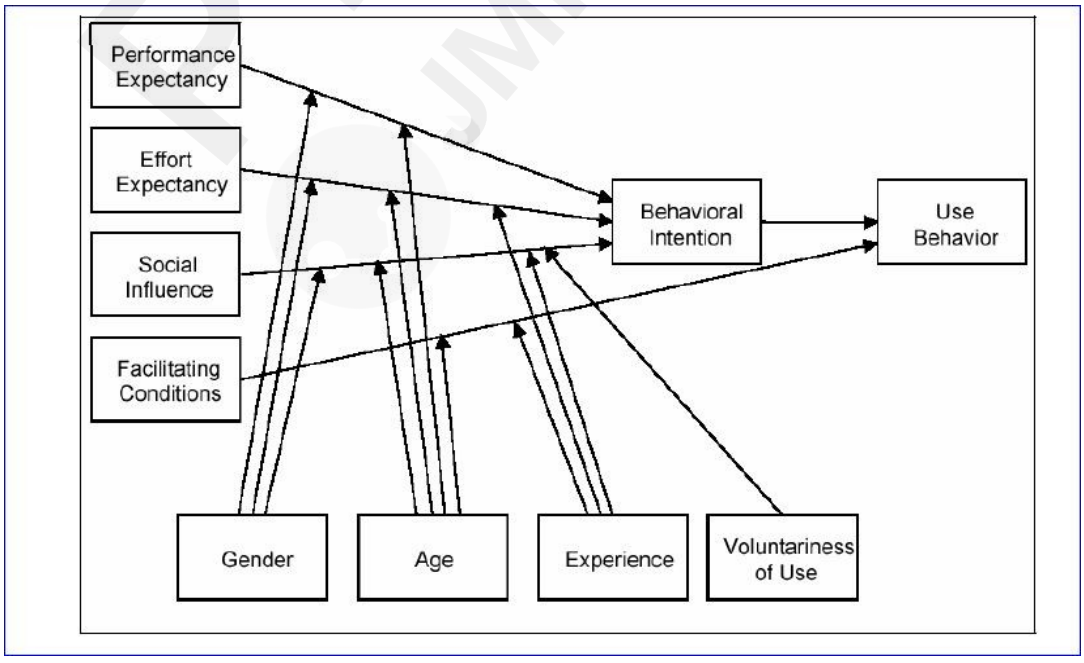
A technology or innovation can only be considered useful if it is accepted and actually used in daily clinical practice. There are several criteria to consider in predicting whether the users will actually use the technology. The theoretical model of Unified Theory of Acceptance and Use of Technology (UTAUT) [12] was used as a framework to provide guidance on the development of the TR in HA. The UTAUT is a model formulated based on conceptual and empirical similarities of various technology acceptance models [Fig. 1]. The model contained four core determinants which are (1) Performance Expectancy (Ease of Use); (2) Effort Expectancy (Perceived Usefulness); (3) Organizational Facilitating Conditions; (4) Social Influence. These four are direct determinants of

user's intention to use and actual use behavior of the new technology [12]:

- Performance Expectancy is defined as the degree to which an individual believes that the use of the new system will help him/her to improve job performance.
- Effort Expectancy is defined as the degree to which a person perceives the system as easy to use.
- Social influence is defined as the degree to which an individual perceives that important others believe he/she should use an information system.
- Organizational Facilitating Condition is defined as the degree to which an individual believes an organizational and technical infrastructure exists to support the use of the system .

The determinants of performance expectancy, effort expectancy, organizational facilitating condition and social influence were taken as reference as they are significant factors affecting technology acceptance of health care workers [13]. These four guiding principles indicated that (1) the new technology should be easy to use; (2) can help therapist to provide treatment to patients in need; (3) adequate support and training should be provided; (4) user should be well engaged and perceived the importance to use the TR. By adhering to these principles, we hoped to foster the intention of use and actual use of TR. The use behaviour and actual use statistics would be reported in outcome of this study. The whole approach was user centric and close collaboration with clinical users and patients was maintained during the course of the entire project development.

Fig. 1. UTAUT Model [12]

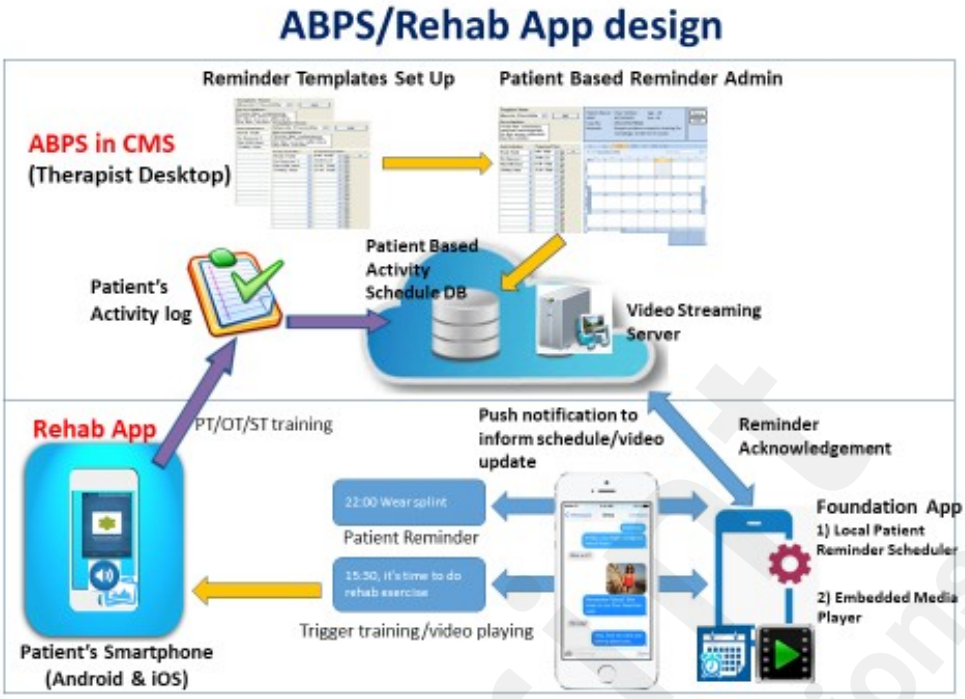


1. Requirement Collection and Design

Focus groups were formed to work in close collaboration with Physiotherapist (PT), Occupational Therapist (OT) and Speech Therapist (ST). The development adopted an agile approach so that therapists could test the prototypes during regular focus group meetings and provide feedback. Moreover, patients were invited to try the mobile app and provide comment on regular basis for continuous user interface improvement.

There are different types of TR serving patients for Stroke [14, 15 16], Cardiac Rehabilitation [17, 18, 19, 20], Total Knee Replacement and Total Hip Replacement [21, 22, 23, 24], Multiple Sclerosis [25, 26], Aphasia and Speech Disorders [27, 28, 29], Cognitive Impairment [30, 31] , Fracture Hip [37, 38] etc. The modes of TR they can be grouped into (1) Videoconference; (2) Virtual Reality; (3) Sensors and Wearables; and (4) Mobile App [9, 10]. Different types of TR have their own advantages and weaknesses. Several randomized controlled trial studies have demonstrated clinical evidence in effectiveness of TR [21, 22, 26]. It was stressed by our users that TR should: (1) bridge the service gap in the ambulatory rehabilitation service; (2) enable the therapists to prescribe suitable exercise to patients; (3) save time of the therapist in view of their current heavy workload. It was emphasized that patients should be able to carry out prescribed rehabilitation activities anywhere and anytime by themselves. TR using off the shelf technology was more favorable [19, 32] because it was easily accessible to patients without the need to procure and install sophisticated equipment. After thorough discussions, a new prescription platform together with a mobile app were to be developed. The utilization of a mobile app in TR has been supported in many studies [30, 31]. After the therapist assessed the patient, exercise videos and reminders were prescribed through a prescription platform, and the patient can then access the prescription through the mobile app. The prescription platform should be easily accessible and aligned well with existing clinical workflow of therapist. The mobile app should be user friendly to elderly users and be able to capture the patient's performance and sequentially feedback to the prescribing therapist for evaluation and treatment planning. The team finally concluded upon a design based on the collective requirements (Fig. 2)

Fig. 2. ABPS/Rehab App system design



2. The Activity Based Prescribing System (ABPS)

The Clinical Management System (CMS) is the Electronic Medical Record (EMR) that all therapists in HA use day in and day out for clinical practice. An EMR refers to the organizational framework for the dissemination of electronic health care information or clinical data across health-related institutions and systems to enhance patient care [33]. The ABPS was specifically built to integrate into the CMS so that the therapist needed no further logon and could view patient information, perform electronic documentation and prescribe rehabilitation activities on the same platform. The CMS password also contains information on the user's profession. Thereby the system only displayed prescription material specific to that profession. Six tab pages were built inside the ABPS, all designed to follow the workflow sequence of therapist:

- New activity (App. 1): for videos and reminders selection
- History (App. 2): all prescribed activities to the patient will be displayed and therapist can choose to repeat ordering if needed.
- Template (App.3): therapist can prescribe pre-set personal or departmental templates
- Patient based calendar (App.4): therapist could view all prescribed activities to patients at a glance. This allowed better distribution of patient schedule and prevents overlapping of prescription.
- Prescribed Activities (App. 5): allocate appropriate parameters to the prescription, such as

treatment period, frequency and timeslot.

- Performance (App. 6): to view performance of patient for prescribed training

In essence a therapist can complete a prescription with a few clicks. Altogether, 144 videos were incorporated into the ABPS. The ABPS was designed as a generic prescription platform so that it allowed: (1) future addition of training videos and reminders; (2) future inclusion of more Allied Health professions.

3. The Rehabilitation App

Patients using TR could be the elderly who may have cognitive impairment or poor memory. Thus, the mobile app was designed to be simple and barrier-free. If a therapist prescribed a training video to a patient, a notification would be pushed to the app at the prescribed time. A swipe on the notification message can trigger the training videos without need of an app logon (Fig.3). The patient could also receive reminders on a regular basis, such as a reminder to wear a splint; wearing pressure garment; carrying out oral hygiene or the use of proper walking aids etc. Moreover, a daily and weekly activity page was included to facilitate the patient's viewing of their own rehabilitation schedule. Visual encourage in the form of a thumb-up was displayed on the app if the patient had completed all prescribed training activities (App. 7).

Fig. 3: Push notification to trigger training video

4. Staff engagement strategy and technical support

OT, PT and ST staff committees were engaged to encourage therapists to participate in design, testing and finally to use the TR. Senior management also expressed that TR was a corporate direction and therapists were encouraged to use this new technology. During the rollout of TR, onsite support was provided to all hospitals. In addition to this, user guides and support hotline

were provided to therapists. Training video was also made available to patients. This was to ensure adequate support to both therapists and patients.

5. Privacy and data security

Privacy and data security were essential concern in the development of TR [7]. All data in the TR platform adopted proper encryption and was stored in server with restricted access. Security scanning was performed according to HA standardization and regulation. Servers and databases were hardened for security, and firewall protection was also implemented. Even-though the app was designed for easy access, this mode only allowed patient to view training videos. If patient needed to access his calendar or other app functions, full logon was still required. This balanced between quick access to training without jeopardizing privacy. Moreover, the push notification on mobile phone was generic and would not carry information on disease and training details.

6. Data analysis

Data analysis would focused on a comparison of TR use before and during the COVID-19 outbreak. Pre outbreak analysis pertained to the period from Oct 2019 to Jan 2020. Outbreak period analysis pertained to period from Feb 2020 to July 2020.

The analysis was targeted to investigate the prescription rate of TR to patients and what types of patients were prescribed most. Moreover, was there any difference in prescription of TR among three professionals? Finally, were the therapists and patients satisfied about the TR? Comparative analysis of five outcomes included:

1. Throughput: the prescription rate of TR
2. Patient demographic: the demographic of patients prescribed for TR
3. Patient conditions: patient conditions that TR was prescribed
4. Workforce: the utilization of the TR by the three workforces (OT, PT, ST)
5. Staff and patient satisfaction: satisfaction of therapist and patients towards TR

Satisfaction surveys were prepared and forwarded to both therapists and patients for collecting their opinion on the Rehab App. The format of the surveys was discussed in the focus group. Therapists suggested that the surveys should be simple and requiring only a short time to complete. The survey for the therapists consisted of 8 questions (Table 7) whilst the survey for patients consisted of four questions (Table 8). A five-point scale was use in the survey (1=

strongly disagree, 2= disagree, 3= neutral, 4= agree, 5= strongly agree). A prompt would be shown on ABPS 30 days after the therapist started the prescription. The prompt contained a reminder to invite the therapist to complete the survey. As for patients, 7 days before the prescription of rehabilitation activity end, a prompt would be shown in Rehabilitation App to invite the patient to complete the survey.

Statistical Analysis:

1. Due to the nature of the data collected was non-parametric categorical type, Chi-square analysis was selected. The Chi-square test were conducted to variables of patient demographic, workforce analysis and patient conditions. Significance was tested at p value less than 0.05, confidence interval at 95%.
2. If Chi-square analysis for workforce analysis and patient conditions was statistical significant ($p < 0.05$), adjusted residual value was measured to identify further difference. Statistical significance was set at < -1.96 and > 1.96, confidence interval at 95%.
3. All data was analyzed using IBM SPSS Statistics version 26 (IBM Corp, Armonk, NY, USA).

Results

The impact of COVID-19 Outbreak

The HA announced an emergency level response on 25 January 2020. Since then there has been severe service disruption into rehabilitation services. In early February 2020, there were around 50% reduction in service output of PT and OT and around 70% reduction in ST due to (1) cancellation of Allied Health Out Patient appointments (AHOP); (2) suspension of all day rehabilitation services from Geriatric Day Hospital (GDH), Rehabilitation Day Program (RDP) (3) suspension of rehabilitation placement to patients discharged from hospitals; (4) suspension of all home visits. In this context, PT, OT and ST expressed the imminent need to expand use of TR to tackle service disruption from early February 2020 onward.

Due to the expansibility design of the TR, urgent addition of new training video was performed. PT added forty one musculoskeletal training videos in early March and fifteen more musculoskeletal training videos in April. ST added eight swallowing training videos in mid-March. OT added eight pulmonary training videos in early April. A total of seventy two videos were added from February to April.

1. Throughput Analysis

The number of prescription per month showed a slightly decrease trend from October 2019 to January 2020. The number of new patients prescribed per month increased to 462 in February 2020 and spiked to 2024 in March 2020. TR was used extensively to combat disruption to the rehabilitation service during the outbreak. The total number of patients prescribed accumulated to 9101 (Fig. 4) by end of July. The prescription rate dropped in April when the outbreak in Hong Kong came under better control . From mid-April to May, there were twenty six days of zero confirmed case. Despite there was another spike of outbreak in July, the trend of prescription was stable in the months from May to July. PT was the profession with highest increase in TR prescription (Fig. 5). Up till end of July, a total of 131995 training videos were prescribed and the overall compliance rate of patients toward prescribed rehabilitation activity was 81.7%.

Fig. 4. No. of patients prescribed for TR per month

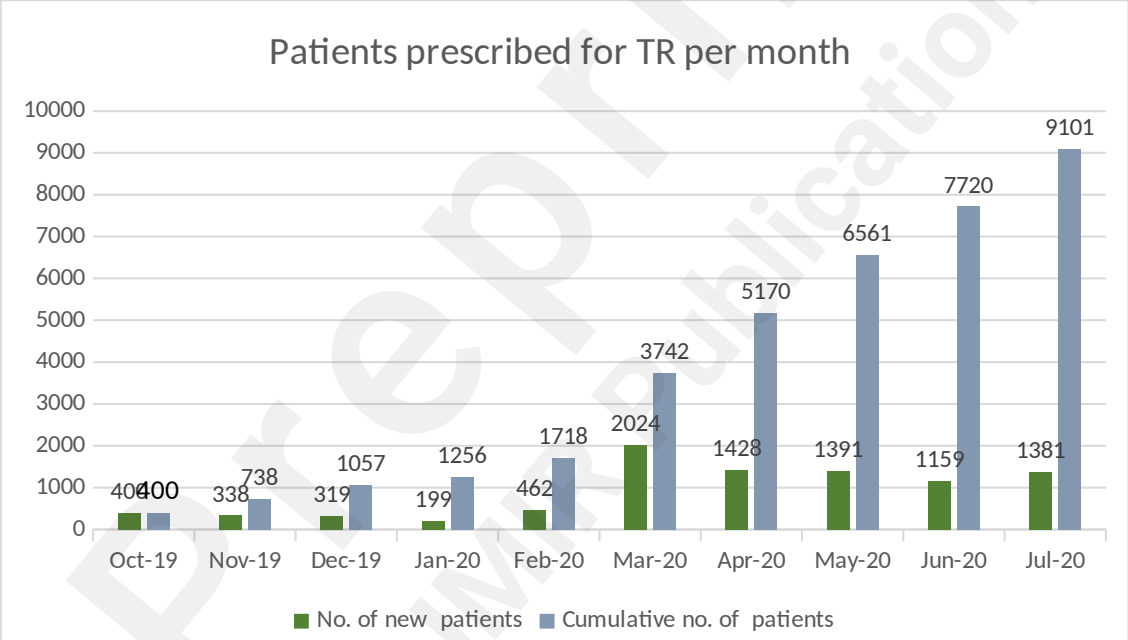
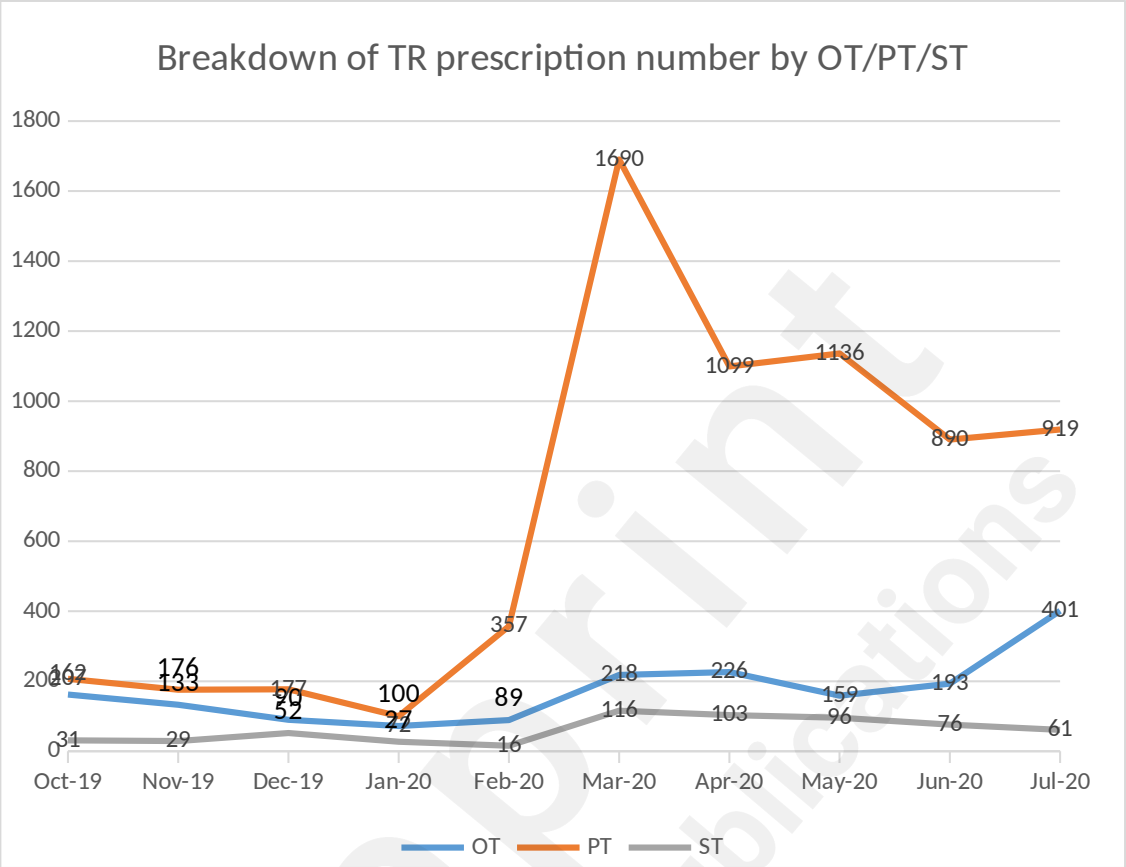


Fig. 5. Breakdown of TR prescription number per month by professions



2. Patient Demographic Analysis

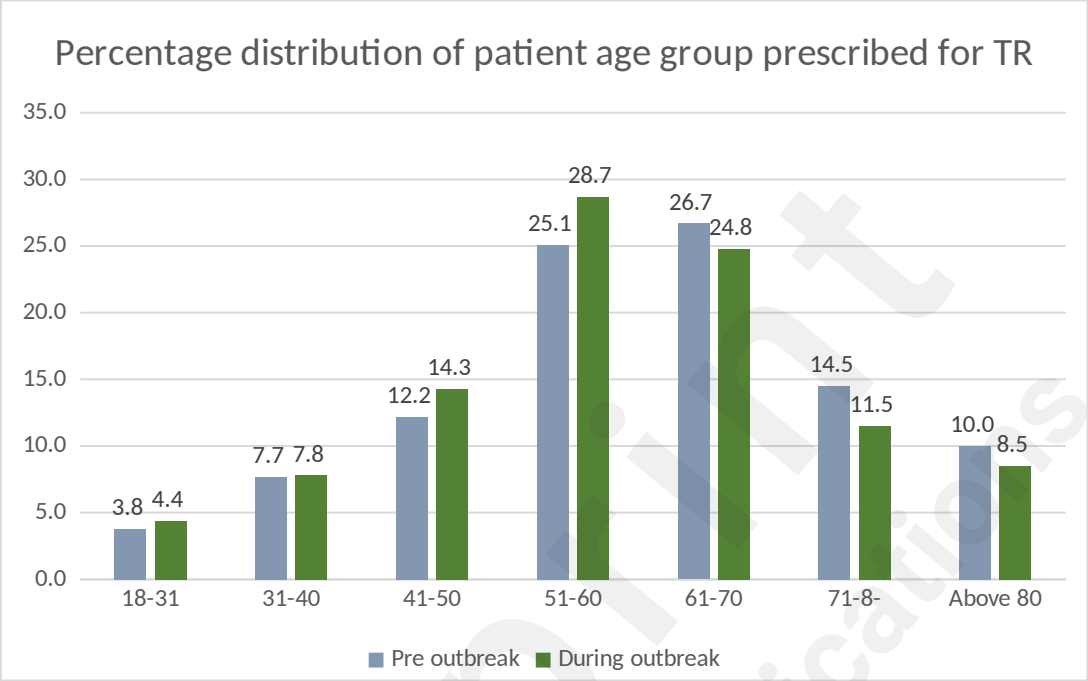
The rehabilitation app was designed for adult patients and the age of prescribed patients ranged from 18 to 106 years old. Age group analysis of patients revealed that before the outbreak, the overall age group with the highest prescription rate was 61-70 (Fig. 6). While during the outbreak the overall age group with the highest prescription rate was 51 to 60. Before the outbreak, 48.8% of patients were below 60 years of age. After the outbreak, 55.2% of patients were below 60 years of age. Chi Square analysis was used to compare the difference in gender, age distribution above and below 60, before and during outbreak periods. There was no statistically significant difference detected in both areas (p=0.828 and p=0.358)(Table 2).

Table 2. Patient demographic analysis

	Pre outbreak	During outbreak	P Value
Gender (n [%])			
Female	648 [52]	4158 [53]	0.828
Age distribution [%]			P Value
Below 60	49	51	
Above 60	55	45	0.358

Mean (SD)	60 (15.5)	59 (16.2)	
Median	61	60	

Fig. 6. Pre and during outbreak age distribution of patients prescribed for TR



3. Patient Conditions Analysis

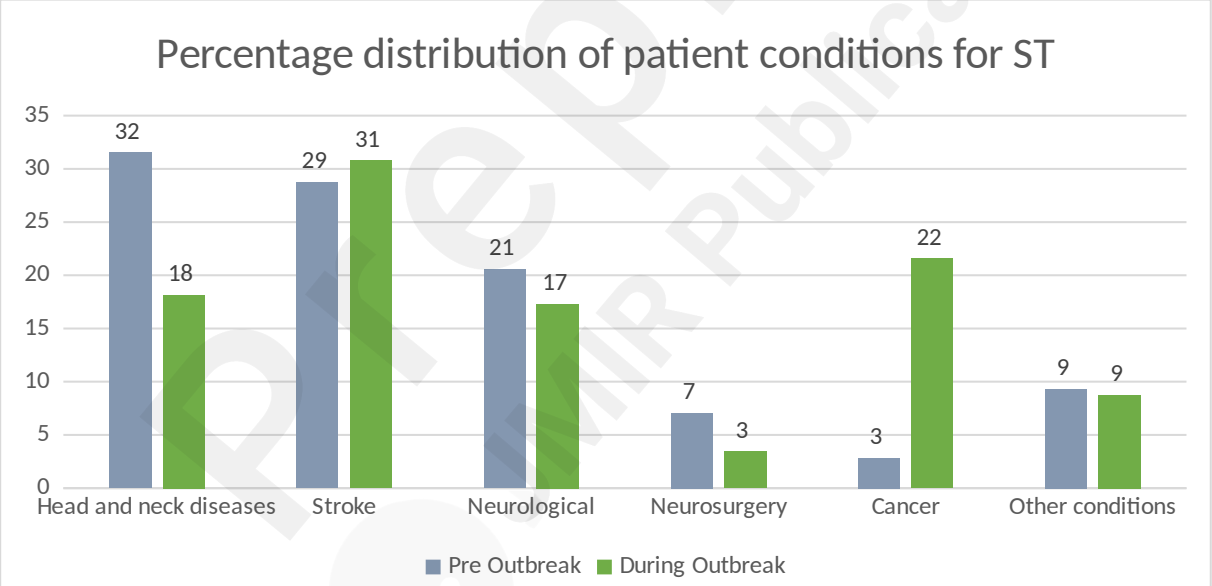
Speech Therapy

ST had a relatively simple patient conditions distribution. The main conditions were head and neck diseases, stroke, neurological conditions, neurosurgery and cancer. Stroke and head and neck disease remained the largest case group for ST throughout (Fig. 7). The average number of patients prescribed per month before the outbreak was 35.5; whereas the number increased to 117 during the outbreak (Table 3). There was increase in prescription per month (230%). Chi square analysis of pre outbreak and during the outbreak patient conditions distribution demonstrated no statistically significant difference (p=0.998). Although there was remarkable difference in mean number of patients prescribed between pre outbreak and during outbreak periods, there was no significant difference in distribution statistically.

Table 3. Patient conditions analysis of ST

Patient conditions	Mean pre outbreak patient no. per month (Oct 19 – Jan 20)	Mean during outbreak patient no. per month (Feb 20 – July 20)	P Value
Head & Neck Diseases	11.2	21.3	0.998
Stroke	10.2	36.0	
Neurological	7.3	20.3	
Neurosurgery	2.5	4.0	
Cancer	1.0	25.3	
Other conditions	3.3	10.3	
Total Count	35.5	117.0	

Fig.7. Percentage distribution of patient conditions pre and during outbreak for ST



Occupational Therapy

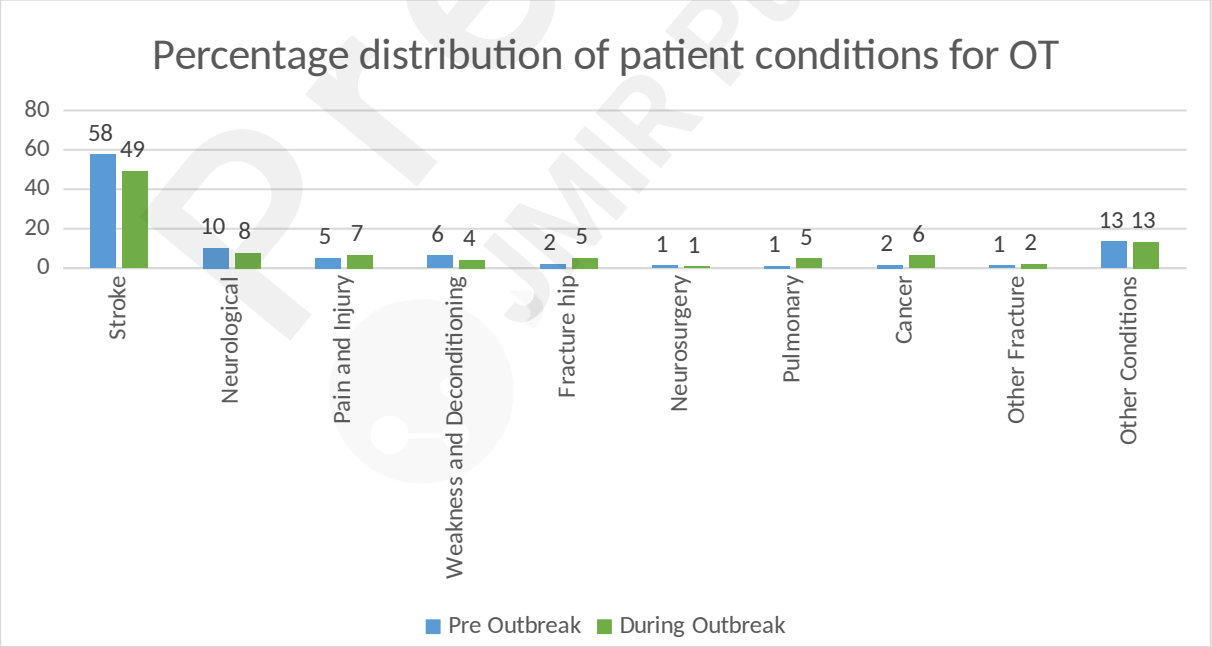
OT had several major patient condition groups including stroke, neurological conditions, weakness and deconditioning, pain and injury, cancer and fractures cases (Fig. 8). Stroke was the condition that constituted over 50% of total prescriptions whereas fracture hip constituted only 2%. The average number of patients prescribed per month before the outbreak was 118, whereas the average number of patients prescribed per month during the outbreak was 214. There was increase in prescription per month (81.8%) (Table 4). Chi square analysis of pre outbreak and during

outbreak patient conditions distribution demonstrated no statistically significant difference (p=0.932). Although there was remarkable difference in mean number of patients prescribed between pre outbreak and during outbreak periods, there was no significant difference in distribution statistically.

Table 4. Patient conditions analysis of OT

Patient conditions	Mean pre outbreak patient no. per month (Oct 19 – Jan 20)	Mean during outbreak patient no. per month (Feb 20 – July 20)	P Value
Stroke	68.0	105.3	0.932
Neurological	12.0	16.3	
Pain and Injury	6.0	14.2	
Weakness and Deconditioning	7.5	8.7	
Fracture hip	2.5	11.0	
Neurosurgery	1.5	1.8	
Pulmonary	1.3	10.3	
Cancer	1.8	13.8	
Other Fracture	1.5	4.5	
Other conditions	15.8	28.3	
Total count	117.9	214.3	

Fig. 8. Percentage distribution of patient conditions pre and during outbreak for OT



Physiotherapy

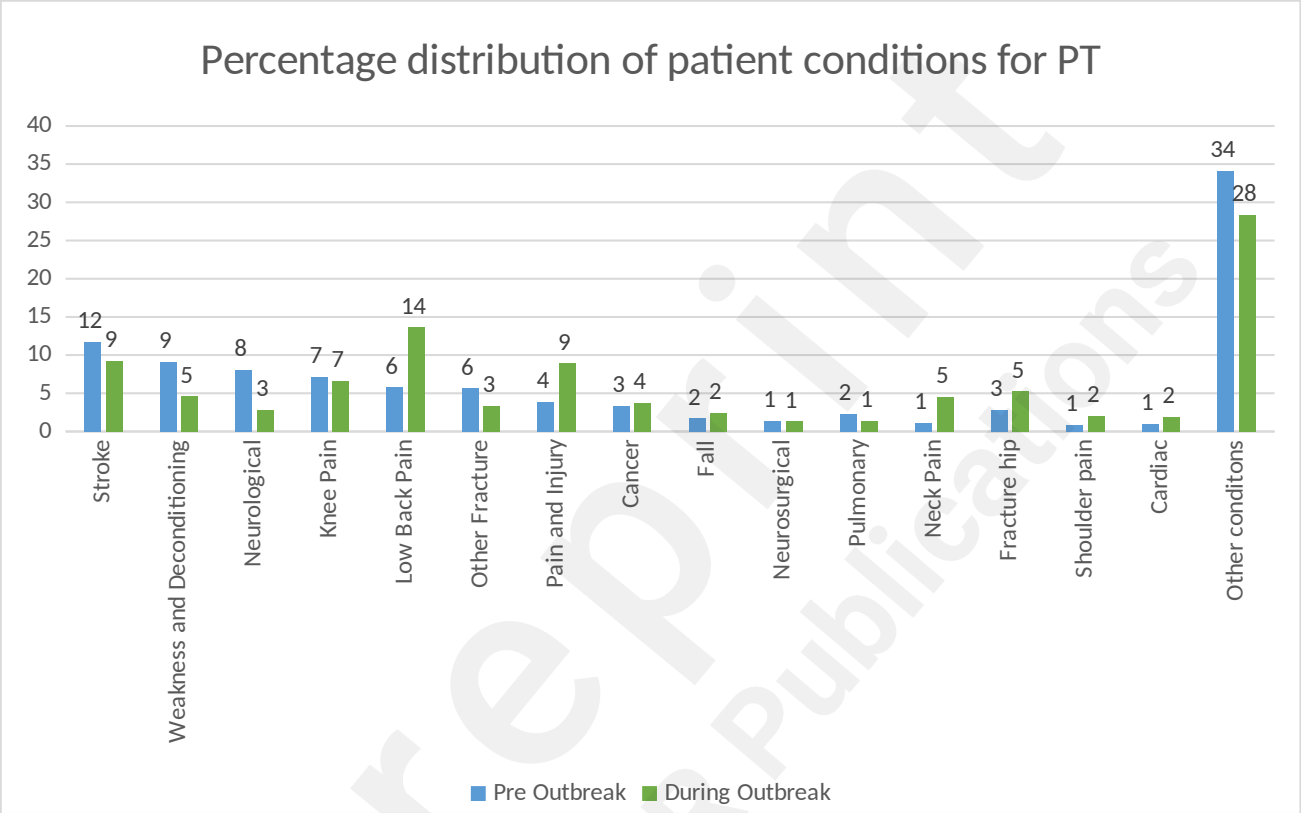
PT had a diverse patient conditions distribution. There were several major client conditions including stroke, weakness and deconditioning, fracture hip, pain and injury, neurological conditions and low back pain (Fig. 9). The most prescribed condition was stroke before outbreak (12%) whereas the most prescribed condition after outbreak became lower back pain (14%). Other than the conditions related to frail elderly, the hip fracture only constituted 3 % pre outbreak and 5% during outbreak. There were many conditions related to musculoskeletal problems in PT. It was also noticed that other conditions occupied the highest percentage throughout pre and post outbreak. Other conditions contained a large variety of musculoskeletal conditions including soft tissue problems and degenerative problems of many body regions. The average number of prescription per month before the outbreak was 174, whereas the figure increased to 1015 per month during the outbreak. The average number of prescription per month increased after the outbreak (484%) (Table 5). Chi square analysis of pre outbreak and during outbreak patient conditions distribution demonstrated there was statistically significant difference ($p<0.05$). Further analysis by adjusted residual value demonstrated (1) statistically significant decrease in weakness and deconditioning (adjusted residual value 2.5, -2.5) and neurological condition (adjusted residual value 3.4, -3.4); (2) statistically significant increase in lower back pain (adjusted residual value -2.9, 2.9), pain and injury (adjusted residual value -2.2, 2.2) and neck pain (adjusted residual value -2.1, 2.1). This was also demonstrated by the percentage change in distribution in these conditions.

Table 5. Patient conditions analysis of PT

Patient conditions	Mean pre outbreak patient no. per month (Oct 19 – Jan 20)	Mean during outbreak patient no. per month (Feb 20 – July 20)	P Value	Adjusted residual value
Stroke	20.3	93.3	<0.05	0.9, -0.9
Weakness and Deconditioning	15.8 (9.1%)	46.8 (4.6%)		2.5, -2.5*
Neurological	14.0 (8.0%)	29.2 (2.9%)		3.4, -3.4*
Knee Pain	12.3	67.0		0.1, -0.1
Lower Back Pain	10.0 (5.7%)	138.5 (13.7%)		-2.9, 2.9*
Other Fracture	9.8	34.2		1.5, -1.5
Pain and Injury	6.8 (4.0%)	90.3 (8.9%)		-2.2, 2.2*
Cancer	5.8	37.7		-0.2, 0.2
Fall	3.0	24.2		-0.5, 0.5
Neurosurgical	2.5	13.3		0.5, -0.5
Pulmonary	4.0	14.3		0.9, -0.9
Neck Pain	2.0 (1.1%)	46.0 (4.5%)		-2.1, 2.1*
Fracture hip	5.0	53.2		1.3, -1.3

Shoulder pain	1.5	20.3	0.8, -0.8
Cardiac	1.8	19.5	0.8, -0.8
Other conditions	59.3	287.3	1.5, -1.5
Total count	173.9	1015.2	

Fig. 9. Percentage distribution of patient conditions pre and post outbreak for PT



4. Workforce Analysis

As of February 2020, there were totally 907 OT, 1177 PT and 112 ST employed in HA. A total of 1112 therapists (372 OT, 635 PT, 105 ST) from various ranks prescribed TR to patients which constituted 50.6% of the total workforce. PT and OT had a three tiers rank structure (rank I, II and senior). Rank II was the entry rank while rank I was the middle rank. ST had two tiers rank structure, the basic rank and the senior rank. Detailed breakdown revealed that ST had the highest overall prescription rate of 93.8%; PT had 54.0% and OT had 41.0% (Fig. 10). Chi Square analysis demonstrated statistically significant difference in prescriptions within OT ($p=0.001$) and PT ($p<0.05$) and no statistically significant difference in ST ($p=0.449$). Further analysis by adjusted residual value demonstrated that there were statistically significant different in prescription between OT II and Senior OT; and statistically significant difference between PT II, PTI and Senior PT (Table 6).

Fig. 10. Overall percentage of TR Prescription by 3 AH workforces

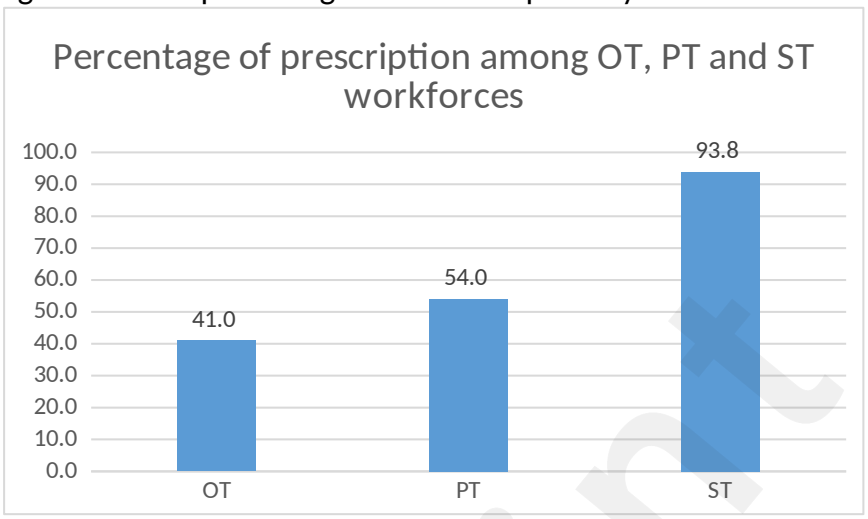


Table 6. Analysis of prescription according to rank of therapist

Rank	Total number of workforce	Workforce prescribed TR	Percentage of prescription	p value (Chi Square)	Adjusted residual value
OT II	442	201	45.5	0.001	2.7, -2.7
OT I	389	154	39.6		0.8, -0.8
Senior OT	76	17	22.4		3.5, -3.5
PT II	554	350	63.2	0.000	6.0, -6.0
PT I	524	266	50.8		2.0, -2.0
Senior PT	99	19	19.2		7.3, -7.3
ST	104	97	93.3	0.449	0.8, -0.8
Senior ST	8	8	100		0.8, -0.8

Satisfaction Survey of therapist and patient on the Rehabilitation App

A total of 111 therapists completed the survey. The response rate was 5.2 percent. The overall satisfaction toward the Rehabilitation App was 3.7 (Table 7). It was opined from therapists that they needed to use considerable amount of time to instruct and assisted patients to install the Rehabilitation App. The preparation work was regarded as increased workload to therapists. In addition, several meetings with therapists revealed that they required further expansion of video library in order to prescribe training to more variety of conditions. Survey showed that therapist found the Rehabilitation App an effective mean for patients to continue rehabilitation in home

setting.

Table 7. Score of therapist survey

	Therapist (n=111)	score
1	The installation procedures are easy to administer	3.5
2	The training app is well organized.	3.8
3	The training app is user-friendly	3.6
4	The content of the app meets the patient's training need	3.7
5	The app can enhance patient's treatment frequency apart from regular treatment	3.8
6	The app could facilitate you to prescribe the home program	4.2
7	The app could assist you in treatment planning	3.8
8	Overall, you satisfy with the training app.	3.7

The response from the patient's side was very positive, with 2623 patients completing the survey. The response rate was 30 percent. Overall satisfaction rate was around 4.2 (Table 8). Several commendation letters were received regarding the Rehabilitation App and most patients found the app to be user friendly and helpful.

Table 8. Score of patient survey

	Patient (n=2623)	score
1	The training app is easy to use.	4.2
2	The training app improves my participation in the home program.	4.2
3	The training app is helpful for my rehabilitation.	4.1
4	Overall, I am satisfied with the training app.	4.2

Discussions

Principal results

Use of TR had increased remarkably during the COVID-19 pandemic. PT was the profession with the highest prescriptions. TR was mostly prescribed to patients between 51 to 70 years of age. Patients registered a high satisfaction rate to TR. Over fifty percent of the total workforce prescribed TR to patients. Originally, TR was designed to treat stroke, fracture hip and frail elderly patients. Our study showed that TR can be used for a much wider spectrum of patient conditions. The generic design of the TR is able to expand training content and cope with the service demand for rehabilitation during the outbreak period.

Utilization of TR before and during outbreak

As showed in our study, TR utilization reached the peak in March 2020 during the first wave of outbreak in Hong Kong. Despite the fact that there was 26 days zero confirmed case period from April to May and a later severe rebound of confirmed cases in July. The trend dropped from 2024

new patients in March to around 1300 from April to July. The stable trend indicated that TR was used stably in service provision irrespective of number of confirmed cases. Continuous monitoring is needed to study the sustainability of utilization and especially during the post pandemic phase.

Our study showed that there was no difference in distribution between patients above or below 60 years old. This echoed with the study of Crotty et al [32] that age of patient is not really a barrier on the acceptance of TR. 2623 patients responded to the survey and overall satisfaction score for the app was 4.2 out of 5 (Table 8). Moreover, the overall compliance rate of TR in our study was recorded at a satisfactory level of 81.7 %. This provided a more reliable reflection on the high acceptance of TR by patient. On the other hand, only 111 therapists responded to the survey and the overall satisfaction score of therapist for the app was 3.73 (Table 7). In fact, the design of the survey question to therapist has serious shortcoming in that it focused on the app rather than ABPS. It was inappropriate for therapist to provide opinion on using the app. A more comprehensive and appropriately designed survey would be needed to reflect the opinion of therapist on ABPS.

Analysis of workforce data demonstrated that 50.6% of the total workforce prescribed TR. There was significant difference in prescription rate between basic rank and senior rank in OT and PT. There was an obvious difference in prescription rate of TR among the three allied health professions (OT 41.0%, PT 54%, ST 93.8%) (Fig. 10). ST had the most serious description in service during the outbreak which could attribute to the highest rate of prescription. There was a highest absolute number of prescriptions among PT, this was attributable to fact that PT was the largest workforce and the extensive use of TR for musculoskeletal conditions. The differences however also raised the question of whether TR was equally suitable to different allied health service nature. For example, TR in the form of a video may not fit activity of daily living training which requires the use of tool and equipment. Whereas for physical training prescribed by PT and oral-motor training prescribed by ST, video training could be a more suitable format.

Analysis of clinical conditions revealed that there was remarkable increase in prescription to stroke during outbreak period (1.55 folds increase in OT, 4.60 folds increase in PT and 3.53 folds increase in ST). This aligned well with the initial goal of the TR. However, it was noticed that hip fracture ranked rather low in the prescription rate for both PT and OT which was surprisingly not aligned to the objective of development. On the other hand, it was noted that both PT and OT had a broad spectrum of clinical conditions prescribed for TR. Further looking into PT other conditions revealed that it contained a wide array of clinical conditions. Statistical analysis revealed that there

was significant increase in prescription to musculoskeletal conditions of lower back pain, neck pain and pain and injury. The result demonstrates that TR is indicative for a broader spectrum of patient conditions.

TR system design

The generic design was adopted to both the ABPS and mobile app. This enabled rapid expansion of training content. Previous studies on TR often require the use of sophisticated communication tool, equipment or software [10, 19, 21, 26, 31]. During the crisis situation of COVID-19 outbreak, the use of off the shelf technology and expansibility of our TR design enabled provision of rehabilitation service to large amount of patients. In addition, Hong Kong has one of the highest ownership rate of smart phone in Asia. The 2018 report of the Hong Kong Census and Statistics Department shows that for Hong Kong citizens over 10 years old, 88% of female and 91% of male own a smart phone [33]. This high ownership of smart phone can be a facilitating factor for our TR.

Opportunities and challenges

The Covid-19 pandemic has shattered healthcare delivery globally. Severe restriction such as social distancing and the suspension of rehabilitation services are presented to prevent spread of disease. The World Health Organization has recommended to postponing treatments considered not urgent in order to ensure safety, still guaranteeing the essential rehabilitation services [39]. The pandemic has catalysed the rapid adoption of telehealth worldwide [40]. TR is regarded as promising new opportunity to overcome service disruption during the outbreak [41,42]. Implementation of TR has been recommended by different Allied Health professions [41, 42, 43, 44].

Through the advent of technology, faster internet connection, cheaper smart devices (smartphone, tablets), and new software are available. TR is able to offer many benefits. However, there are challenges ahead if TR is to be used extensively in the future. For example, the use of TR is a paradigm shift for therapists from their conventional face to face intervention to tele intervention. During the outbreak, there was a rapid increase in the number of therapist who needed to use TR. Consequently, training and accrediting staff to use TR became essential. A ‘train the trainer” model can be a feasible model to allow rapid staff development to enable trained staff to onboard others in the use of TR [41]. There was concern from HA that the pandemic may fluctuate and could last for some time so there would be high utilization of TR. Consequently, the training and support to

therapist to use TR was considered important. As many Allied Health professions are a predominantly hands-on and skill-based profession, the lack of physical contact with patients is a hurdle for TR utilization. Thus, essential infrastructure enhancement for future TR development includes patient evaluation, assessment, physiologic monitoring and education [41]. Moreover, legislation, payment arrangement should be in place to facilitate TR delivery [40, 41].

The COVID-19 pandemic does not affect acute outbreak period alone but may also create a serious backlog of rehabilitation cases in the post pandemic recovery period, which is referred to as “care debt” [40]. A massive rehabilitation service demand can emerge after the outbreak. To transform TR from crisis mode during pandemic to sustainable mode after outbreak requires clear deliberation and planning.

Limitation of study

This observational study has a number of limitations. This study only reports outcomes of TR utilization before and during outbreak periods. It does not cover the clinical effectiveness of TR to patients and this required further well powered clinical studies. The UTAUT is used as a guiding framework for development of the TR. It is a limitation that this model is not used to evaluate the acceptance of this new technology. The design of the survey questions also carries serious shortcoming. The study period is relatively short and sustained utilization of TR would need longer study. More meaningful information can be gathered if the study is extended to the period when COVID-19 pandemic is over.

Conclusions

COVID-19 pandemic has seriously affected rehabilitation delivery. Our study has shown that TR has been used extensively and effectively during the outbreak period to mitigate service disruption. Besides the original targeted conditions of stroke and hip fracture, TR has been prescribed to a large variety of clinical conditions. The PT has the largest number of prescription and TR has been used extensively to musculoskeletal conditions. Our study also shows that patients have good acceptance to TR. Although TR cannot replace all face to face rehabilitation service, it has played an important role in the pandemic period. In addition, TR in the form of generic prescription platform and mobile app can be one of the effective means to provide rehabilitation services to patients. The TR developed has demonstrated its huge potential particularly in the crisis situation of COVID-2019 outbreak and has promising potential to become a sustainable service delivery model.

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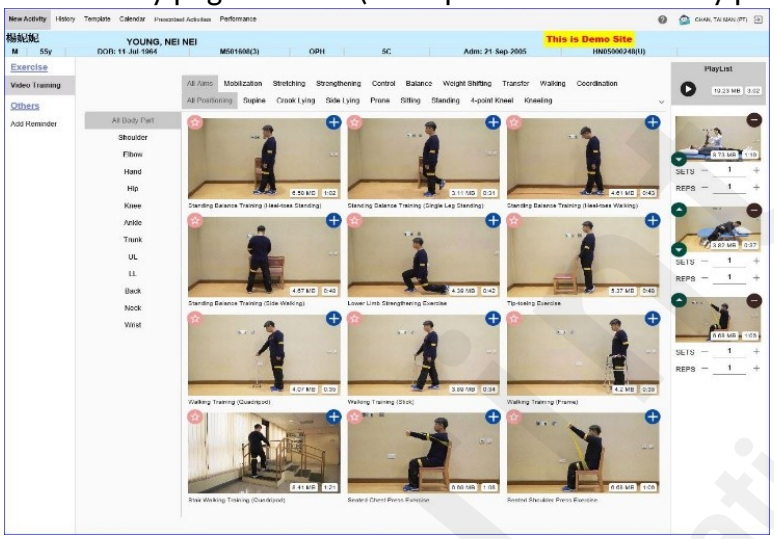
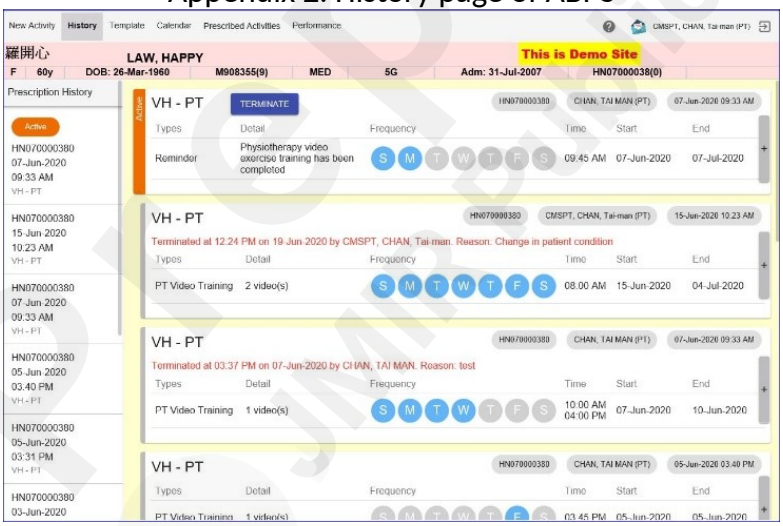
Appendix

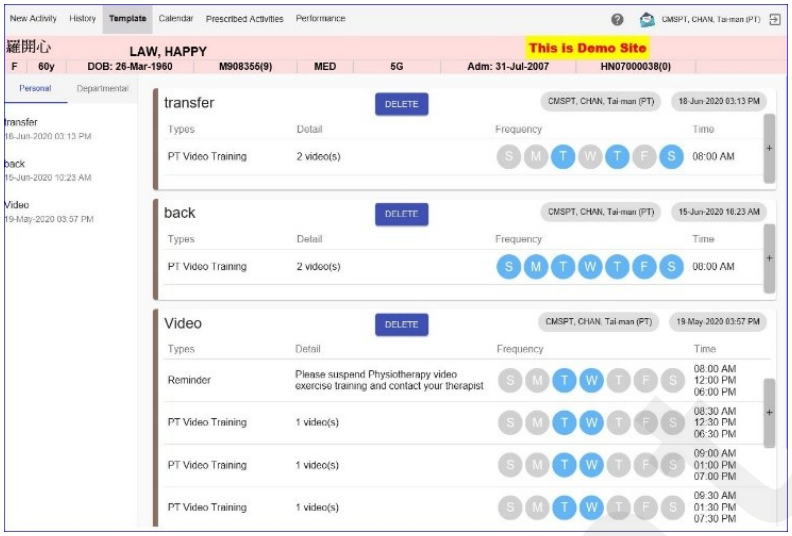
Appendix 1. New Activity page of ABPS (Therapist can add video by pressing + icon)



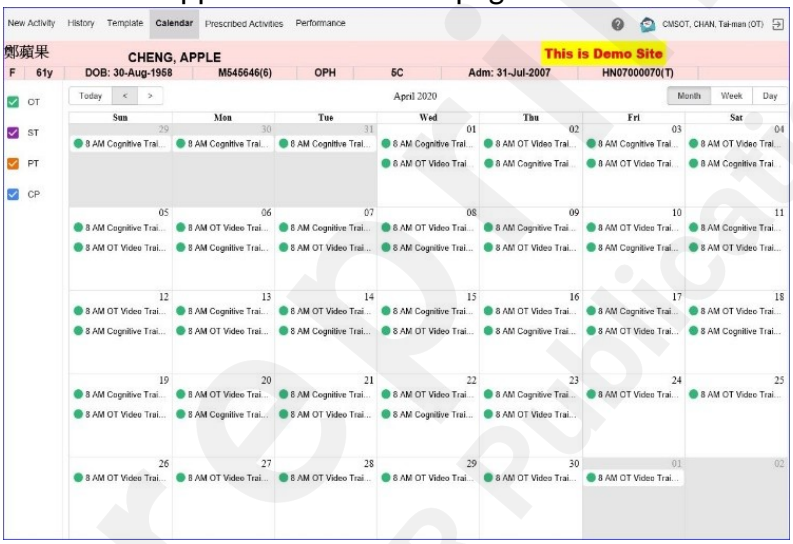
Appendix 2. History page of ABPS



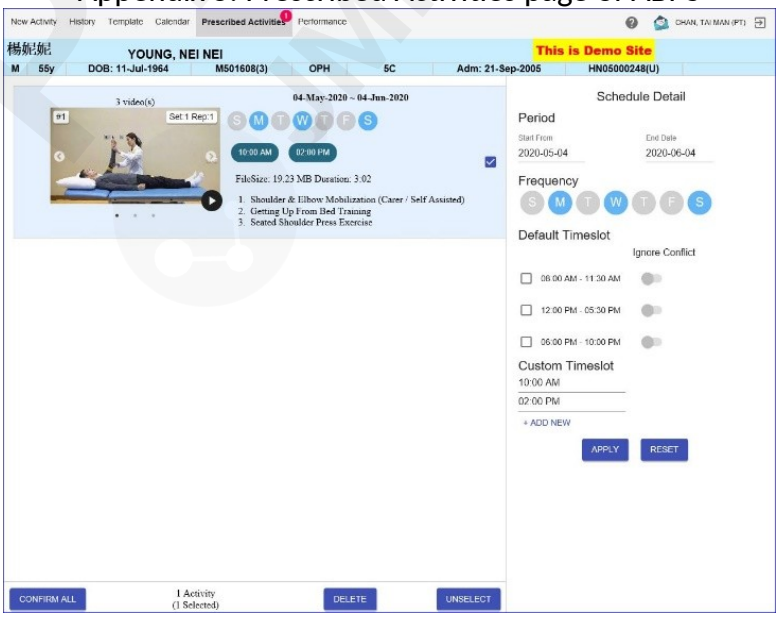
Appendix 3. Template page of ABPS



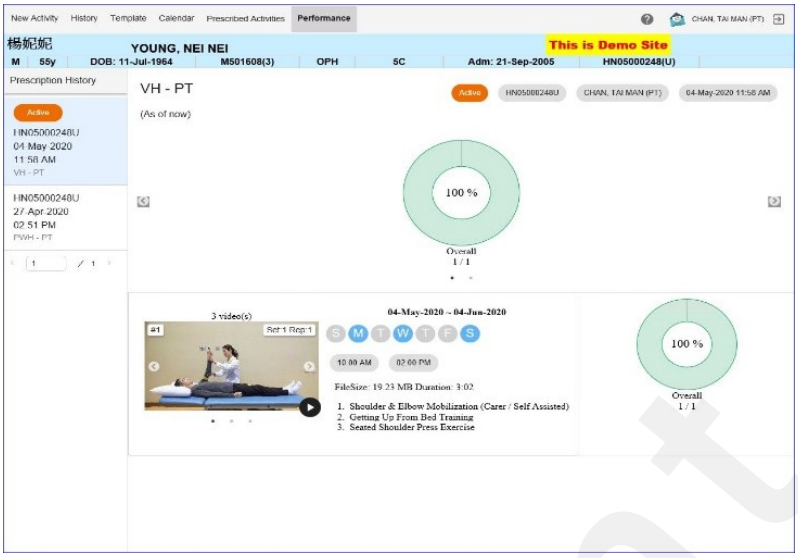
Appendix 4. Calendar page of ABPS



Appendix 5. Prescribed Activities page of ABPS



Appendix 6. Performance page of ABPS



Appendix 7: Thumb up encourage to patient