Singapore’s Tele-Rehabilitation (TR) Experience: Preliminary Results and Steps Forward
The Basis for Telerehabilitation

- Singapore and Hong Kong both have an ageing population.
- The incidence and prevalence of disability increases with age.
- Rehabilitation reduces the burden of disability but...
  - Only a quarter of patients continue with centre-based rehabilitation after discharge
  - Home rehabilitation is expensive
- At a cost between the cost of centre and home based rehabilitation, telerehabilitation may improve:
  - Access to rehabilitation and subsequent independence.
  - Transition of rehabilitative care from hospital to home.
Telerehabilitation

Can we use instead:

• *Training* for patients & caregivers on use of telerehabilitation system before discharge to home;

• *Live real-time video-conferencing* (e.g. FaceTime on iPads);

• *Sensors* to capture *physical data* to help therapists assess recovery process and prescribe next level of exercises;

• *Pushing training videos of* therapist-prescribed exercise *to patients*?
Telerehabilitation

• Since 2010, National University of Singapore has been developing a tele-rehabilitation system in collaboration with acute and community hospitals in Singapore
• Incorporates previously mentioned elements
• Its efficiency was evaluated in a time motion study.
• Its effectiveness is currently being evaluated in a randomized controlled trial which will end in Dec 2016.
Mdm Doris Zen’s Story

(1:48)
How the Telerehabilitation System Works

(1:11)
Accuracy of Sensors (Upper Extremities, UE)

Figure 4(a)

Upper Extremity Sensor-Goniometer Plot for Range of Motion for All Joints in 19 Normal Subjects

$r_p^2 = 0.97$

$r_p^2$ denotes Pearson's correlation coefficient.
Accuracy of Sensors (Lower Extremities, LE)

Figure 4(b)  Lower Extremity Sensor-Goniometer Plot for Range of Motion for All Joints in 19 Normal Subjects

$r_p^2 = 0.99$

$r_p^2$ denotes Pearson’s correlation coefficient.
Singapore Tele-technology Aided Rehabilitation in Stroke (STARS) Study: A Randomized Controlled Trial

**Primary hypothesis**
Among stroke survivors, a tele-rehabilitation intervention involving video-conferencing with a therapist and use of wearable monitoring devices during the first three months after stroke results greater functional recovery at three months, compared to usual care.
Study Workflow

Assessed for eligibility

Excluded
- Did not meet eligibility criteria
- Declined to participate
- Other reasons

Randomization

Allocation to tele-rehabilitation intervention for 3 months involving:
- Baseline assessment
- Daily exercise using iPad-based system with recording of daily exercise (video and sensor data)
- Weekly video-conference with tele-therapist after review to video and sensor data collected
(N=50)

Allocation to usual care (N=50)

Follow-up at 3 & 6 months

Lost to follow-up (with reasons)
Discontinued intervention (with reasons)

Lost to follow-up (with reasons)
Discontinued intervention (with reasons)
Preliminary Results

• The primary time-point for outcomes in the RCT is 3 months and the target size is 50 controls and 50 intervention subjects based on sample size calculations.

• These are the results of the interim mid-term analysis of 30 subjects recruited (14 control and 16 intervention subjects):
  – Of the 14 control subjects, 2 subjects defaulted follow-up, leaving 12 control subjects available for analysis for data at 3 month time-point.
  – Of the 16 intervention subjects, 2 subjects defaulted follow-up, leaving 14 intervention subjects available for analysis for data at 3 month time-point.

• Statistical significance cannot be assessed in this interim analysis because target sample has not been reached and hence current sample size is not powered.

• This interim analysis only reports preliminary primary findings.
## Difference in Barthel Index (BI) score between baseline and three months

<table>
<thead>
<tr>
<th>Group</th>
<th>Mean Change</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Usual Care</td>
<td>-0.75</td>
<td>The tele-rehabilitation group improved in the functional status by 9.07 BI points, while the usual care declined by 0.75 BI points.</td>
</tr>
<tr>
<td>Telerehabilitation</td>
<td>+9.07</td>
<td></td>
</tr>
</tbody>
</table>

(Barthel Index (BI) ranges from 0 to 100. The higher the improvement in Barthel Index score, the greater the functional improvement.)
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<tr>
<th>Group</th>
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<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Usual Care</td>
<td>+2.4</td>
<td>The tele-rehabilitation group continued to improve between 3 and 6 months, even after tele-rehabilitation ended at 3 months.</td>
</tr>
<tr>
<td>Tele-rehabilitation</td>
<td>+11.50</td>
<td>(Barthel Index (BI) ranges from 0 to 100. The higher the improvement in Barthel Index score, the greater the functional improvement.)</td>
</tr>
</tbody>
</table>
 Attendance at day rehabilitation centre during study

• At recruitment, 42% of controls were going for day outpatient rehab but only 14% of tele-rehab subjects were going for day outpatient rehab (which is expected as the tele-rehab group were already receiving tele-rehab).

• In contrast, at three months, 33% of controls were going for day outpatient rehab (a drop from 42%) but 64% of tele-rehab subjects (an increase from 14%) continued rehabilitation (after tele-rehab stopped) by going for day outpatient rehab.
Attendance at day outpatient rehabilitation during study

• It seems that without tele-rehab, patient in usual care remain disabled and continue to face physical barriers to getting to day outpatient rehab centre from persistent disability.

• In contrast, the tele-rehab group improves in physical function and possibly starts a positive feedback cycle whereby they become more independent and more motivated to do more rehab to the extent that when tele-rehab stops at 3 months, they choose to continue rehab at the day outpatient rehab centre thereafter to 6 months.

• A qualitative study on participants after completion of trial to explore their experience with tele-rehab and reasons why both groups continue with day outpatient rehab to 6 months.
Time Motion Study

• We also conducted a time motion study comparing the time spent and tasks executed during tele-rehabilitation in comparison with day outpatient and home rehabilitation.

• We measured the time spent by therapists and their therapy assistants, if applicable) on tasks of a typical rehabilitation session with a stroke patient who may be accompanied by a caregiver such as a family member or domestic helper, in the 3 settings:
  1. Home rehabilitation;
  2. Day outpatient rehabilitation;
  3. Tele-rehabilitation
## Time Motion Study Results

<table>
<thead>
<tr>
<th>Form of Rehabilitation</th>
<th>Mean (SD) Time Spent per Rehab Session (mins)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Therapist</td>
</tr>
<tr>
<td>Day Outpatient</td>
<td>70.1 (7.3)</td>
</tr>
<tr>
<td>Home</td>
<td>79.1 (10.6)</td>
</tr>
<tr>
<td>Tele-Rehab</td>
<td>47.6 (13.5)</td>
</tr>
</tbody>
</table>
Time Motion Study Results

• *Post-hoc analysis*: Even after excluding traveling time (patient traveling time in DR and therapist traveling time in HR), the duration of TR sessions still remained shorter than those of DR and HR.

• TR offers significant time savings for therapists compared to HR, and for patients compared to DR, not only by eliminating unproductive traveling time but also by independently increasing therapist efficiency.
Singapore’s Telemedicine Strategy

• **Health IT Master Plan**
  - National Electronic Medical Record (EMR) System
  - Infra-structure [e.g. New Generation Broadband Network (NGBN)- 1Gps; 90% home coverage]

• **Telemedicine**:
  - National Telemedicine Guidelines (March 2015)
  - MOHH Telemedicine Planning Office
  - National Telemedicine Implementation Workgroup (TIW)
National Telehealth Pilot Programmes

• National Telemedicine Implementation Workgroup (TIW) recommended *tele-rehabilitation* to be pilot tested on multiple sites and larger sample population to assess its suitability to be implemented as a national tele-health programme.

• *Video-conferencing* for national healthcare system and *tele vital sign monitoring (VSM)* were the other two telehealth initiatives shortlisted by the TIW for further assessment.

• *Requests for Proposals (RFP) for TR service and evaluation* was called on December 2015 to January 2016.
National Tele-Rehabilitation Pilot Programme

• Aim: To assess if TR-supported (enhanced) day outpatient and home rehabilitation is as effective as usual care range of 9 broad conditions:
  1. Stroke
  2. Fractures
  3. Lower limb joint replacement (e.g. hip and knee)
  4. Lower limb amputations
  5. Pneumonia,
  6. Falls
  7. Cancer
  8. Deconditioning
  9. Musculoskeletal conditions
National Tele-Rehabilitation Pilot Programme

• The pilot will examine the use of tele-rehabilitation (TR) to replace some rehab sessions in:
  – Day outpatient rehabilitation
  – Home rehabilitation

• A controlled quasi-experimental study design will be used.
National Tele-Rehabilitation Pilot Programme

• The pilot is planned to be implemented in 4 settings sites (5 acute hospitals, 3 community hospitals, 2 nursing homes and 3 day rehabilitation centres) and on at least 750 TR-enhanced patients and 750 usual care (non TR-enhanced) patients over 2 years.

• Other aims:
  – To increase therapists and patients’ exposure to tele-rehabilitation as a new rehabilitation care model
  – Evaluate productivity gains in TR-enhanced rehab using time motion studies
Enrolling patients for tele-rehabilitation through AIC IRMS, taking consent, and making advanced payment. Therapists can prescribe relevant rehabilitation exercises according to patients’ conditions. Patients can make and modify appointment.

Tracking of tele-rehabilitation history, enabling therapists to review and generate patients’ progress reports.

Evaluating the effectiveness of tele-rehabilitation (e.g. through compliance, clinical indicators or client satisfaction.

Identifying who is referred for tele-rehabilitation, assess patients’ conditions, and determine subsidy eligibility.

Involving an initial home visit for set up of equipment at patients’ home, and users training; daily recording of patients using tele-rehabilitation system to perform the prescribed exercises; and weekly virtual consults. Therapists adjust prescribed exercises according to patients’ progress.

Returning the equipment to provider, and for therapist to arrange follow up care for patients.
## Common workflow for Tele-rehab

<table>
<thead>
<tr>
<th>Identification</th>
<th>Enrollment &amp; Prescription</th>
<th>Care Delivery</th>
<th>Outcomes Tracking</th>
<th>Patient Discharge</th>
<th>Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Patient Identification</strong></td>
<td><strong>Patient Information</strong></td>
<td><strong>Inventory Management</strong></td>
<td><strong>Data Transmission</strong></td>
<td><strong>Reports</strong></td>
<td><strong>Programme Effectiveness</strong></td>
</tr>
<tr>
<td>- Restructured hospitals</td>
<td>- AIC IRMS (personal particulars, referral source, medical history)</td>
<td>- Inventory mgmt</td>
<td>- Transmit data via 3G/4G gateway, wifi</td>
<td>- Discharge summary</td>
<td>- Tele-rehab sessions actualised</td>
</tr>
<tr>
<td>- Community hospitals</td>
<td>- Patient consent</td>
<td>- Link device to patient</td>
<td>- Interventions actualised</td>
<td>- Referral letters</td>
<td>- Interventions actualised</td>
</tr>
<tr>
<td>- Nursing homes</td>
<td>- Condition specific rehab prescription</td>
<td>- Device collection</td>
<td>- Integration to EMR/NEHR</td>
<td>- Service package (with/without iPad)</td>
<td>- Tele-rehab indicators</td>
</tr>
<tr>
<td>- Day rehab centres</td>
<td>- Service package (with/without iPad)</td>
<td>- Technical support (onsite/online)</td>
<td>- Patient functional recovery</td>
<td>- Polyclinics</td>
<td>- Patient functional recovery</td>
</tr>
<tr>
<td>- Home care on CHAS</td>
<td>- Treatment duration</td>
<td>- Appointment booking</td>
<td>- AIC IRMS (personal particulars, referral source, medical history)</td>
<td>- GPs on CHAS</td>
<td>- Patient satisfaction survey</td>
</tr>
<tr>
<td>- GPs on CHAS</td>
<td>- Patient profile, caregivers availability</td>
<td><strong>Care package</strong></td>
<td><strong>Set up &amp; training</strong></td>
<td><strong>Inventory collection</strong></td>
<td><strong>Patient Satisfaction</strong></td>
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<td><strong>Stratification</strong></td>
<td><strong>Billing &amp; payment</strong></td>
<td><strong>Therapist Consultation</strong></td>
<td><strong>Tracking</strong></td>
<td><strong>Alert</strong></td>
<td><strong>Subsidy Eligibility</strong></td>
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<tr>
<td>- Disabling conditions, functional status</td>
<td>- Treatment costs</td>
<td>- Video conferencing</td>
<td>- Patient treatment compliance status</td>
<td>- Sub-optimal rehab exercise movement detection (Analytics)</td>
<td>- Subsidies (financial info, means-testing)</td>
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<tr>
<td>- Patient profile, caregivers availability</td>
<td>- Subsidies</td>
<td>- Recording</td>
<td>- Patient progress status</td>
<td></td>
<td>- Patient profile, caregivers availability</td>
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<tr>
<td>- Patient profile, caregivers availability</td>
<td>- Medisave, insurance</td>
<td>- Exercise prescription</td>
<td>- Capture of exercise video record</td>
<td>- AIC IRMS (personal particulars, referral source, medical history)</td>
<td>- Technical support (onsite/online)</td>
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<tr>
<td>- Patient profile, caregivers availability</td>
<td>- Appointment reminder</td>
<td>- Therapist specific “to-review” list</td>
<td>- Clinical notes (observations, prescription)</td>
<td>- Patient consent</td>
<td>- Technical support (onsite/online)</td>
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<td>- Patient profile, caregivers availability</td>
<td>- Event outcome notification</td>
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<td>- Therapist time</td>
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Thank you

Any questions?

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