

## Supplementary file

### Design and development of a mHealth intervention for rehabilitation support after knee replacement: TeleRehabilitation after knee Arthroplasty (TReAT) project

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Table 1-Questionnaire for e-survey among physiotherapists to understand current clinical practice patterns

**General Information**

1. Are you?
  - < 30years
  - 30-40 years
  - Above 40 years
  
2. Sex
  - Male
  - Female
  
3. Check on all the educational qualification
  - 3.1. BPT: Yes/No
  - 3.2. MPT: Yes/No
  - 3.3. Other fellowships related to Physiotherapy: Yes/No
  - 3.4. Research qualification: Diploma/Masters/PhD
  - 3.5. Any other degree \_\_\_\_\_
  
4. Main area of speciality in physiotherapy:
  - Musculoskeletal/orthopaedics
  - Neurology
  - Cardiorespiratory
  - Paediatrics
  - Community Rehabilitation
  - Sports Physiotherapy
  - Geriatric Rehabilitation
  - Obstetrics and gynaecology
  - Not applicable
  
5. Primary place of work:
  - Public hospital
  - Government college
  - Private hospital
  - Private college
  - Private Clinic
  - Research institution
  
6. Years of experience in physiotherapy: .....
7. City/town and state of practicing: .....
8. How many patients with knee replacement do you treat in a week?.....

**Therapeutic Modalities and Exercises**

9. Which of the following **therapeutic modalities** do you use for rehabilitation in the **first few weeks** following knee replacement? *Always/Often/Sometimes/Rarely/Never*
  - 9.1. NMES (neuro muscular electrical stimulation)
  - 9.2. TENS (Transcutaneous electrical nerve stimulation)
  - 9.3. UST (Ultrasound therapy)
  - 9.4. Cryotherapy
  - 9.5. Hot water fomentation

- 9.6. SWD (Short wave diathermy)
- 9.7. MWD (Microwave diathermy)
- 9.8. CPM (Continuous passive mobilizer)

10. Which **type of exercise** do you generally advice for rehabilitation of patients with post knee replacement? *Always/Often Sometimes/Rarely/Never*

- 10.1. Open Kinetic Chain Exercises (OKC)
- 10.2. Closed Kinetic Exercises (CKC)
- 10.3. Closed and open kinetic exercise
- 10.4. Hip muscle exercises
- 10.5. Ankle muscle exercises

11. In which phase of physical rehabilitation do you generally introduce **balance exercises** to patients with knee replacement? *(choose one answer)*

- 11.1. 0 to 3 weeks
- 11.2. 4 to 6 weeks
- 11.3. 7 to 12 weeks
- 11.4. > than 12 weeks

12. How often do you advice the following **functional exercises** to your patients with knee replacement? *Always/Often Sometimes/Rarely/Never*

- 12.1. Stair climbing
- 12.2. Cycling outdoors
- 12.3. Rising and sitting down
- 12.4. Walking exercises outdoor
- 12.5. Any other therapy that is not listed here please specify

13. Among the following which are the most **common tools** you prescribe to patients with knee replacement for homebased exercises? *Always/Often/Sometimes/Rarely/Never*

- 13.1. Thera band
- 13.2. Weight cuffs
- 13.3. Physio cool (ice compression bandage)
- 13.4. Balance Foam
- 13.5. Foam Roller/mini bolster
- 13.6. Any other please specify.....

14. What type of **footwear** do you generally advice for patients with knee replacement?

- Slippers
- Laced shoes
- Unlaced shoes
- Sandals/Ketos
- Don't advice

#### **Progression criteria**

15. Which of the following clinical parameters do you opt as **progression criteria** while treating patients with Knee Replacement? *(Yes/No)*

- 15.1. Pain
- 15.2. ROM
- 15.3. Muscle strength
- 15.4. Functionality
- 15.5. Mental state
- 15.6. Co-morbidities

- 15.7. Compliance to exercises
- 15.8. Any other please specify : \_\_\_\_\_

16. In your practice, do you use any **questionnaire/scale** to assess the patient progression?

- Yes, please specify the name of the scale
- No

### **Perception**

*(In this section we would like to capture "your perception" on available physiotherapy modalities even if you do not use them in your clinical practice).*

17. In your **opinion** how important are the following, for **functional improvement of patient** with knee replacement? Please rate each of the following from 0-100  
*(0-Not at all important, 100-Extremely Important)*

- 17.1. CPM
- 17.2. NMES
- 17.3. TENS
- 17.4. Patella mobilization
- 17.5. Stretching
- 17.6. Hip Abduction/Adduction exercises
- 17.7. Ankle plantar flexors exercises
- 17.8. Core strengthening exercises
- 17.9. Progressive resistance exercises
- 17.10. Eccentric exercises
- 17.11. Concentric exercises
- 17.12. Isometrics exercises
- 17.13. Balance training
- 17.14. Gait re-education
- 17.15. Cardiovascular training
- 17.16. Functional Exercises
- 17.17. Scar massage

18. In your **opinion** how important is **preoperative physiotherapy (Prehabilitation)** on post knee replacement outcomes? (Please rate from 0-100) *0-Not at all important, 100-Extremely Important*

19. In your **opinion** how important is **preoperative education** for rehabilitation post knee replacement **compliance** to rehabilitation? (Please rate from 0-100) *0-Not at all important, 100-Extremely Important*

20. If we plan for a **preoperative education** for effective rehabilitation in knee replacement, which areas would be **helpful** to add in? *(Yes/Definitely Yes/No/Definitely No/Not sure)*

- 20.1. Anatomy of knee joint
- 20.2. How to prepare for surgery
- 20.3. Details of surgical procedure
- 20.4. Process of recovery
- 20.5. Expected functional outcome
- 20.6. Exercise after surgery
- 20.7. Caregiver training
- 20.8. Precautions
- 20.9. When to resume normal activities at home

- 20.10. Pain and wound management
- 20.11. Self-care
- 20.12. Home modification
- 20.13. Activities of daily living
- 20.14. Sports following knee replacement
- 20.15. Squatting and kneeling post knee replacement
- 20.16. Any others that is not listed above. please specify.....

**Contact session**

21. What is the average number of contact session you have with patients following knee replacement:

- 21.1. 1 month \_\_\_\_\_
- 21.2. 2 to 3 months: \_\_\_\_\_
- 21.3. >3 months: \_\_\_\_\_

22. In your practice which modes of contact with patient do you follow? (Yes/No), *Check all that applies*

- 22.1. Face to face in clinic
- 22.2. Face to face at home
- 22.3. Video conferencing
- 22.4. Telephone call

*Table 2-List of proposed topics by physiotherapists for education*

1.	About Knee Replacement
2.	Preparation for surgery
3.	Patient and care giver's role
4.	What happens in the hospital
5.	Surgical wound management
6.	Pain Management
7.	Preventing postsurgical complications
8.	Personal care
9.	Assistive devices for walking
10.	How to avoid falls?
11.	Modifying lifestyle after knee replacement
12.	Items required during rehabilitation period

Table 3-TReAT app notifications and text messages

Theme	Message	Frequency	Timing	Function	To whom
Welcoming to the app	Welcome to the Knee Rehabilitation program	1	After first login	Orientation	Patient
Welcoming to the app	Welcome to the Knee Rehabilitation program! You will be able to see progress of (patient name), and doctor appointments.	1	After first login	Orientation	Family member
Pain	Namaste (Patient Name) Knee pain is normal in the first few weeks after surgery. We hope you are taking the pain medications, applying ice, and exercising regularly	7	After date of surgery	Motivation	Patient
Exercise	Namaste (Patient Name) Don't forget to do your EXERCISES. They are necessary for your recovery	12	After date of discharge	Motivation	Patient
Being connected	Namaste (Patient Name) We hope your knee pain is better and you can do the exercises. If you have any concerns, please send a message to your doctor.	6	After date of discharge	Motivation	Patient
Danger sign	Namaste (Patient Name) Keep the wound dry! If you notice discharge (pus and bloody) or too much pain or excessive redness, please take a photo and send to your doctor.	1	After date of surgery	Awareness	Patient
Move	Namaste (Patient Name) Walk as much as you can within your home!	1	After date of surgery	Motivation	Patient
Move	Namaste (Patient Name) Do you know climbing stairs is a way of exercise? Use the railing while using the staircase!	6	After date of discharge	Awareness	Patient
Move	Namaste (Patient Name) Try to STEP OUT of your home and go for a walk during daytime!	4	After date of surgery	Motivation	Patient
Scheduled appointment	Namaste (Patient name) Your consultation via video call is fixed by (Physiotherapist/Surgeon name) on dd/mm/yyyy at time HH: MM (12 hr format (AM/PM))	-	-	Notify	Patient

Scheduled appointment	Namaste (Patient name) consultation via video call with (Physiotherapist/surgeon name) is fixed on dd/mm/yyyy at time HH: MM (12 hr format (AM/PM))	-	-	Notify	Family member
Appointment reminder	Namaste (Patient name), Your video consultation with Dr (name) is due at HH: MM (12 hr format (AM/PM)). Be ready for the call.	-	-	Notify	Patient
Appointment reminder	Namaste, (Patient name) video consultation with Dr (name) is due at HH: MM (12 hr format (AM/PM)). Be ready for the call.	-	-	Notify	Family member
Therapy plan	Namaste (Patient name), Your exercises have been updated. Please check and follow as prescribed.	-	-	Notify	Patient
Reminder for pain e-diary	We want to know how you are doing! Can you rate your knee pain in My Diary?	1	After date of discharge	Reminder	Patient
Reminder for pain e-diary-I	We hope you are getting better. It's been 3 days since we heard from you. Can you rate your knee pain in My Diary?	12 (for 1 <sup>st</sup> six weeks)	After date of surgery	Reminder	Patient
Reminder for pain e-diary- I	It's been 3 days since (Patient name), entered their pain score. Please encourage (Patient name) to rate their knee pain so that we know how they are recovering.	12 (for 1 <sup>st</sup> six weeks)	After date of surgery	Reminder	Family member
Reminder for pain e-diary- II	We hope you are getting better. It's been a while since you completed your pain e-diary.	3 (For last six weeks)	After date of surgery	Reminder	Patient
Reminder for pain e-diary- II	It's been a while since (Patient name) has entered their pain score. Please encourage (Patient name) to rate the pain levels so that we know how they are doing.	3 (For last six weeks)	After date of surgery	Reminder	Family member
Reminder for activity and knee function e-diary	We hope you have started walking inside your home. To help us monitor your progress, please complete your activity and knee function regularly in the e-dairy.	1	After date of surgery	Notify	Patients



Reminder for activity and knee function e-diary	We are remotely monitoring how (Patient name) is doing. It will be helpful if you encourage (Patient name) to complete their activity and knee function e-dairy regularly.	1	After date of surgery	Notify	Family member
Reminder for Exercise e-diary	It's been 3 days since you completed your exercise e-diary. We hope you are doing your exercises regularly.	30	After assigned exercises	Reminder	Patients
Reminder for Exercise e-diary	It's been 3 days since (Patient name) has completed their exercise e-diary. Please check with them if they are doing their exercises regularly.	30	After assigned exercises	Reminder	Family member
Activity progress rewards <i>(If patient scores more than the previous activity level. For e.g.: Previous level was 5, but in the next time patient scored 6)</i>	Well done! You seem to be more active. Keep it up!	-	After date of surgery	Motivation	Patient
Exercise progress rewards in a day <i>(When patient performs more than 75% exercises in a day)</i>	Well done (Patient name)! Today you have completed most of the exercises. Keep it up!	-	After assigned exercises	Motivation	Patient
Exercise progress rewards in a day <i>(When patient performs more than 75% exercises in a day)</i>	Today (Patient name) has completed most of the exercises. Keep encouraging them to continue exercising.	-	After assigned exercises	Notify	Family member

Exercise progress in a week <i>(When patient performs less than 75% exercises in a week)</i>	Well done (Patient name) for doing your exercises. You will benefit more if you do it daily and follow all the exercises as prescribed.	-	After assigned exercises	Motivation	Patient
Exercise progress in a week <i>(When patient performs no exercises in a week)</i>	It's been a week since you completed your exercise diary. We hope you are doing your exercises.	-	After assigned exercises	Reminder	Patient
Enrolment <i>(When a new patient is enrolled by the surgeon)</i>	A new patient has been enrolled and is assigned to you in the Knee rehabilitation program.	-	-	Update	Physiotherapist
Date of surgery <i>(When patient's date of surgery is added by the Surgeon)</i>	(Patient name) has undergone surgery on dd/mm/yyyy.	-	-	Update	Physiotherapist
Date of discharge <i>(When patient's date of discharge is added by the Surgeon)</i>	(Patient name) has been discharged from the hospital on dd/mm/yyyy.	-	-	Update	Physiotherapist
Therapy plan	Please check and update the therapy plan of (patient name) if required.	6	Date of discharge	Reminder	Physiotherapist
Appointment	Dr (name), a video consultation is scheduled with (Patient name) at HH: MM	-	-	Reminder	Physiotherapist
Appointment	Your call has started, kindly join	-	Appointment	Reminder	Patient/Physiotherapist

Table 4-Topic guide for patients who used TReAT app completely/partially

**Innovation relative advantage**

1. How has this mobile application helped you in accessing physiotherapy exercises?
  - a. Probe: compared to clinic visits
  - b. Probe: reduced physiotherapist support at any point of time during recovery
  - c. Probe: are they getting physiotherapist exercised done by any informal attendant
2. Has this mobile application helped you in communicating with your doctors?
  - a. Probe: video consultation, messaging
3. Does this app made you feel that you were being monitored by your doctors?
  - a. Probe: even without clinic visits
4. Did your knowledge about this surgical procedure improved with this app?

**Adaptability**

5. Does this mobile application fit your needs of your rehabilitation phase?
  - a. What could have made it more suitable? Probe: paper vs electronic (Diary & education)
  - b. What else should have been part of this app?
6. Due to the enrolment into this mobile based program, did it change your routine clinic visit in any way?
  - a. Do you want to suggest any changes to make it more suitable and adaptable?

**Design and usability**

7. What do you think of the app design?
  - a. Do you like the colour?
  - b. How easy was it for you to go from one screen of the app to another screen?
  - c. What do you think about the appearance and display of the app?
8. Which features of the mobile application was most useful for you?
  - a. Notification, reminders, graphs
9. Is there anything you would want to change in this application?
10. What was your experience about measuring knee movement?

**Local attitudes and conditions**

Tech literacy about the app features (experience of using those)

Probe: Video call, e-material reading, exercise viewing

**Self-efficacy**

11. How easy was it to use this application?
  - a. Probe: any difficulty while using this mobile application? what was the difficulty? How did you resolve the difficulty?
  - b. Probe: any tech assistance required
  - c. Probe: time took to use the app on your own with ease

**Recipient centeredness**

12. If any of your family members/friends undergo knee replacement, would you recommend them to use this app? If no, reason?
  - a. Probe: ask about satisfaction
  - b. Probe: motivation to use this app

**Training**

13. Do you think the training provided to you for navigating the app was enough?
  - a. Probe: about user manual

Table 5-Topic guide for non-users of TReAT app

1. Why didn't you not use the TReAT app?
  - a. Probe: unavailability of smart phone
  - b. Probe: poor tech literacy
  - c. Probe: lack of time
  - d. Probe: unmotivated
  - e. Probe: availed other means of support

Table 6-Topic guide for health care providers

- Innovation relative advantage**
14. Has this mobile application helped you in monitoring and providing rehabilitation support to patients after knee replacement?
    - a. Probe: therapy plan
    - b. Probe: compared to face-to-face consultation
  15. Has this mobile application helped you in communicating efficiently with your patients?
    - a. Probe: video consultation, messaging
- Adaptability**
16. Does this app fit your needs of monitoring patients with knee replacement remotely?
    - a. What could have made it more suitable?
    - b. What else should have been part of this app?
    - c. Do you want to suggest any changes to make it more suitable and adaptable?
  17. Will this app make any changes in your current practice in future?
- Design and usability**
18. What do you think of the app design?
    - a. Do you like the colour?
    - b. How easy was it for you to go from one screen of the app to another screen?
    - c. What do you think about the appearance and display of the app?
  19. Which features of the mobile application was most useful for you?
  20. What was your experience about assigning therapy plan to the patients?
- Training**
21. Do you think the training provided to you for navigating the app was enough?
    - a. Probe: about user manual
- Self-efficacy**
22. How easy was it to use this application?
    - a. Probe: any difficulty while using this mobile application? what was the difficulty? How did you resolve the difficulty?
    - b. Probe: any tech assistance required
    - c. Probe: time took to use the app on your own with ease
- Recipient centeredness**
23. If we get permission to use this app in routine care would you continue to use this application for remote monitoring of patients after this project is over? Why?
  24. Would you recommend this app to your peers this app? If no, reason?
    - b. Probe: ask about satisfaction
    - c. Probe: motivation to use this app

Table 7-Demographic characteristics of enrolled participants (n=30)

PID	Education	Surgery status*	Type of users	Interview participation	App features used
P101	HS	Undergone	Non-users		
P102	PG	Undergone	Full user	Yes	Exercise, Video Consultation, knowledge, My diary, messages
P103	PG	Undergone	Full user		
P104	G	Advised	Non-users	Yes	
P105	PS	Undergone	Partial users	Yes	My diary, knowledge
P106	PS	Undergone	Partial users	Yes	Video Consultation, messaging, knowledge
P107	PS	Undergone	Non-users		
P108	PS	Undergone	Non-users	Yes	
P109	NS	Undergone	Partial users		
P110	G	Undergone	Non-users		
P111	PG	Undergone	Full users	Yes	Exercise, Video Consultation, knowledge, My diary, Range of motion
P112	HS	Undergone			
P113	HS	Undergone	Non-users		
P114	PS	Undergone	Partial users	Yes	My diary
P115	PS	Scheduled	Non-users		
P116	PS	Undergone	Non-users		
P117	HS	Undergone	Non-users		
P118	HS	Undergone	Non-users		
P119	G	Undergone	Partial users	Yes	My diary, Video Consultation, Range of motion, received a notification
P120	HS	Undergone	Partial users		
P121	PS	Undergone	Partial users	Yes	Video Consultation
P122	G	Undergone	Non-users	Yes	
P123	G	Undergone	Partial users	Yes	Video Consultation
P124	PG	Undergone	Partial users		
P125	PS	Undergone	Non-users	Yes	

P126	PS	Undergone	Partial users		
P127	G	Scheduled	Non-users		
P128	PS	Undergone	Non-users		
P129	G	Undergone	Non-users		
P130	HS	Undergone	Partial users	Yes	My diary, Range of motion, Video consultation

\*Surgery status towards the end of pilot phase, M- Male, F-Female, HS- High school; PG- Post-graduation, G- Graduation, PS- Primary school, NS- No school, VC-Video call, ROM- Range of motion

Table 8-Exemplary quotes from patient interviews

<p>Barriers to app usage</p>	<p><b>Had access to private support</b>  <i>"I do not use it mam. I have this person (attendant) who make me to exercise four times a day. I walk now with minimum pain. So, I didn't feel need to use that app. This app will be helpful to the people who do not have any attendant or someone like this what I feel."</i> (P113, 76F)</p>	<p><b>Hectic job, requiring family support</b>  <i>"Actually, what happens is in the morning because of my service it is hectic, so it slipped my mind completely...if kids are around, they point it out, now they point it out on phone and I say I will see, it remains like this only."</i> (P104, 53F)</p>	<p><b>Forgot manual and training due to pain</b>  <i>"..had explained the chair exercise and others from the booklet to me. At that time, I remembered but as there was so much pain at that time I forgot afterwards..."</i> (P104, 53F)</p>
<p>Need for private physiotherapist</p>	<p><b>Provides physical support</b>  <i>"...Like some time, I just lift my legs, or tighten muscles. But I cannot do much. She makes me do more and for more time. I cannot do for so long. When she comes she makes me do... I cannot put as much strength as she does. She bends my knees to maximum. She keeps towel beneath my knees and then instruct me to push it. She presses herself. I cannot put so much of strength."</i> (P106, 71F)</p>	<p><b>Validation of exercise performance</b>  <i>"..The only disadvantage of that is we will not be able to find out where are we wrong and right, as long as there is nobody to guide us. Physiotherapist is close to us and can tell to press more. He makes her exercise based on counting, for example, to press 1, 2, 3, 4 or 5 times, lift up 5 times and bring down 5 times. Gradually they increase it and this can be taught us live, such as we did it 5 times yesterday, so now, we need to do it 10 today, or 15 today..."</i> (P114, 71F)</p>	<p><b>Close relationship</b>  <i>"Actually, he gets a little close to my mom as much as I have observed and keeps a good observation on her, so he makes her exercise fine."</i> (P114 Caregiver)</p>
<p>Perceived benefits of app usage</p>	<p><b>Motivation to do exercise</b>  <i>"The main benefit is because of this app there is push that you must do the exercises, and you have to fill the diary. If by the end of the day you didn't do it, it is like why you didn't do."</i> (P114 Caregiver)</p>	<p><b>Avoid travel</b>  <i>"Till now they've guided us nicely through phone itself. So, this seems good to me that for the people who come from far places and face a lot of trouble can be consulted ... you can virtually meet me from there, since I have to otherwise spend 1-1.5 hours and come there... The patient also suffers less as travelling too far and waiting in queue for 2-3 hours can become a headache for everyone... it seems better as it avoids the</i></p>	<p><b>Improve knowledge</b>  <i>"Yes of course. I feel if you view it once you can do it by self. If by chance you forget it, then again you can refer the videos and can do it again."</i> (P102, 73M)   <i>"I didn't take help from anyone. Just followed what was mentioned in it and I got relief. I am fine now..."</i></p>

		<i>stress that's present in the hospital there."</i> (P114 Caregiver)	<i>that app has so much of information. If one can operate, they can do everything from home itself."</i> (P119, 70M)
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Figure 1-Digital and Health literacy

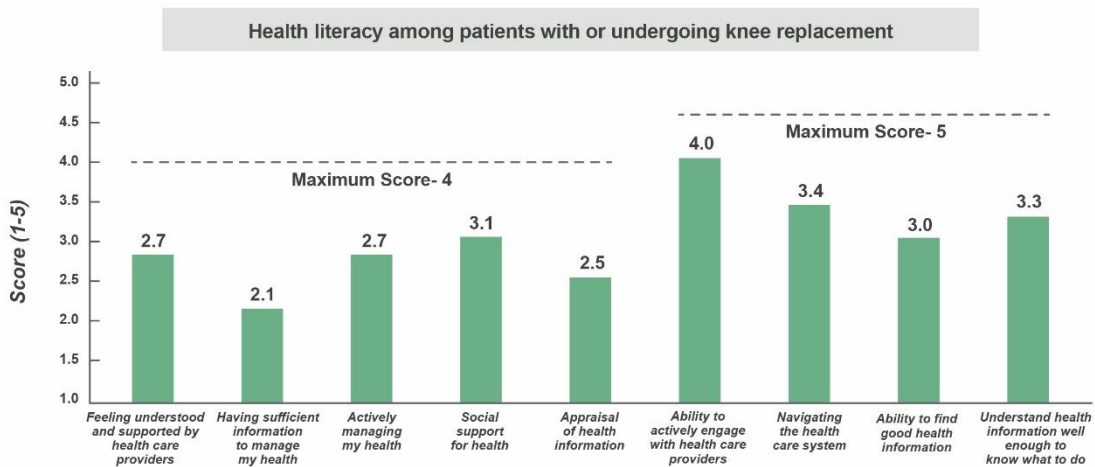
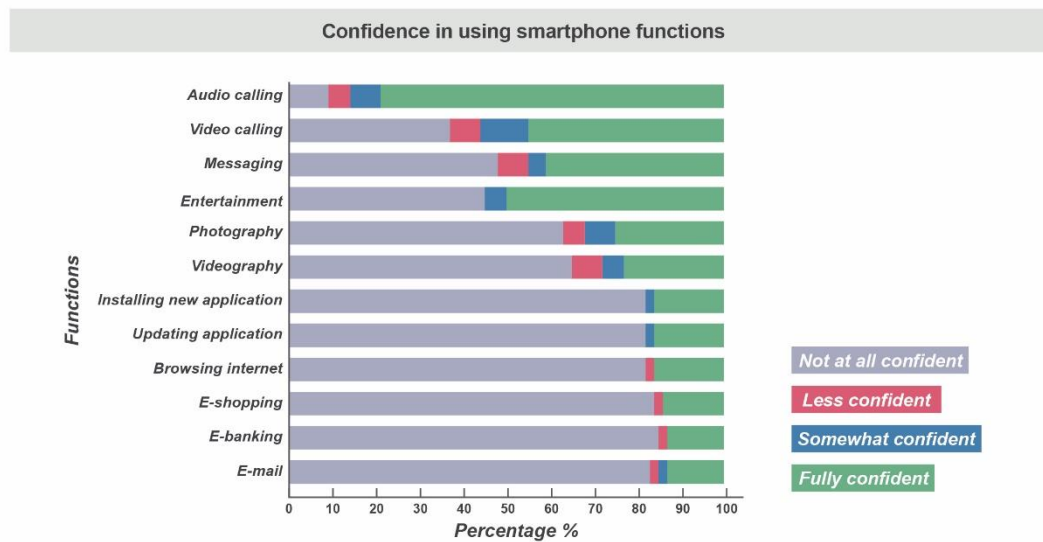
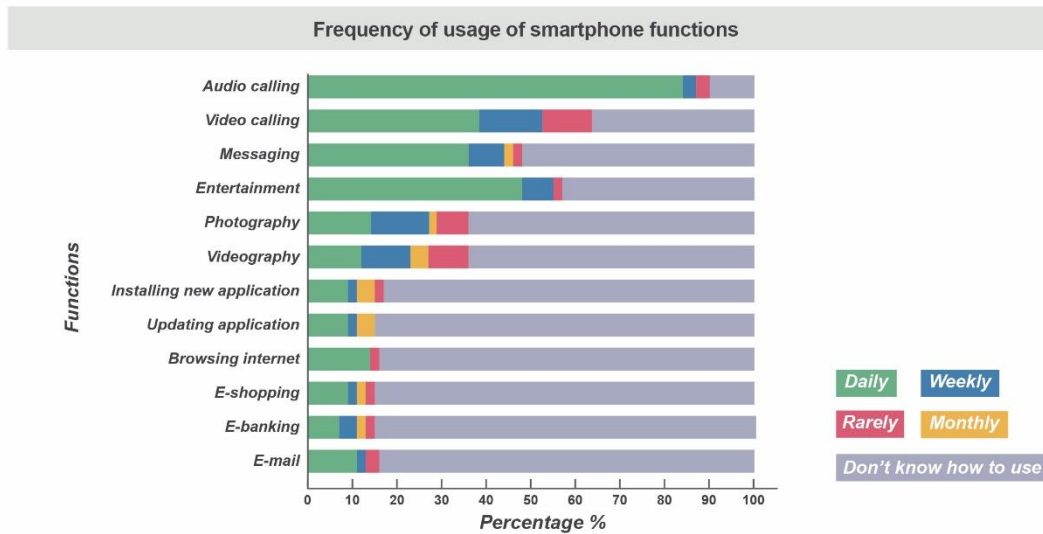
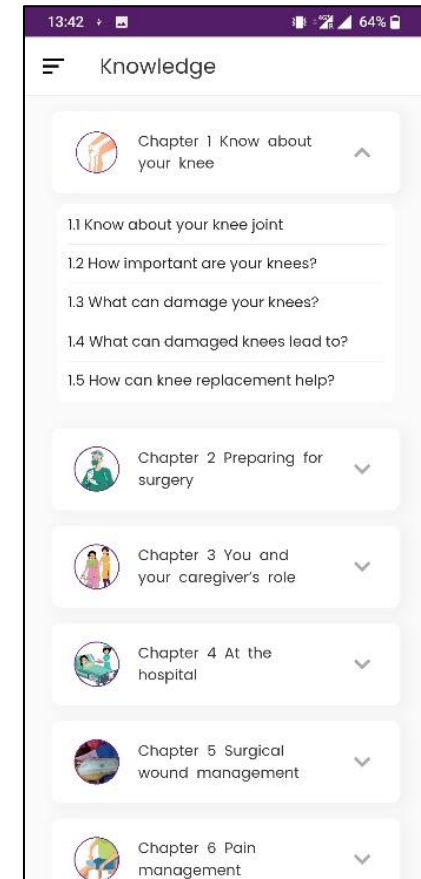


Figure 2-Education booklet in paper and e-format



Legend: Snapshots of education booklet and a screenshot of the app interface

Figure 3-Exercise repository



Left-Snapshot of exercise videos  
Middle-screen of healthcare provider interface where exercise videos are incorporated with thumbnails.  
Right- Patient's view of exercises as per prescription

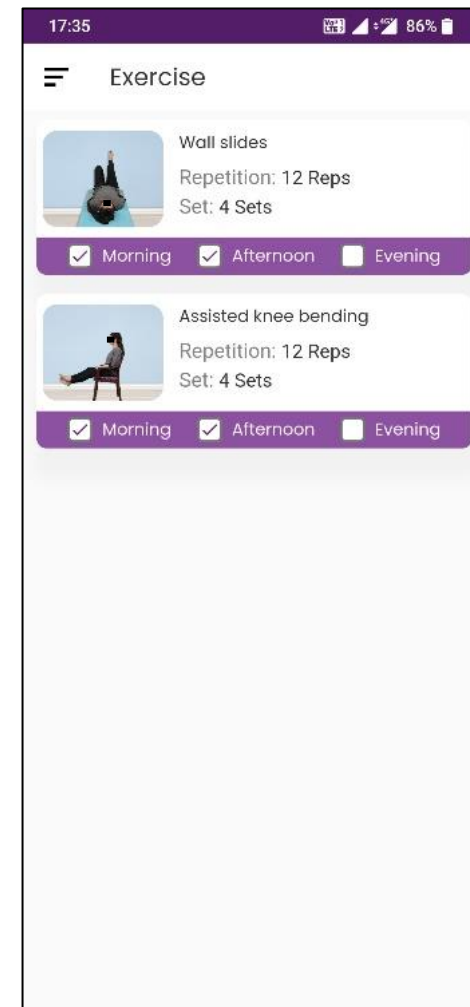
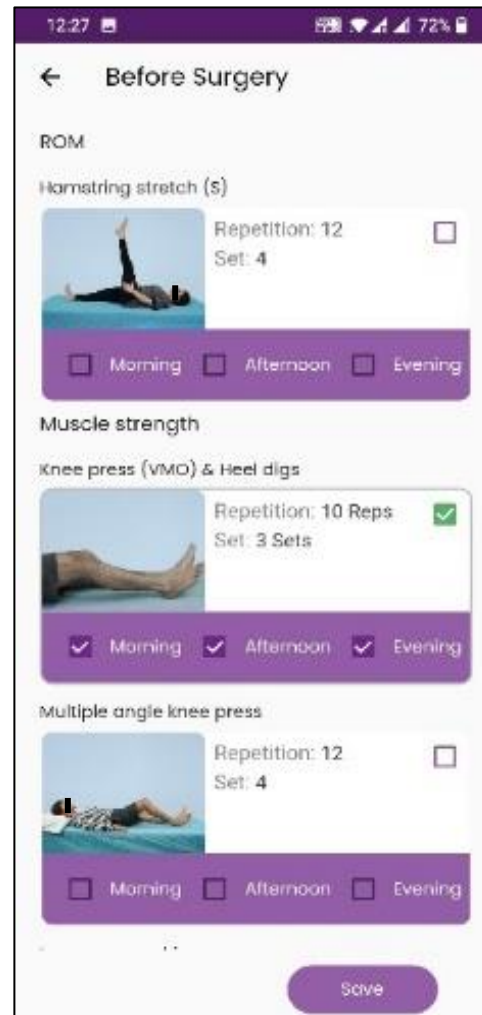
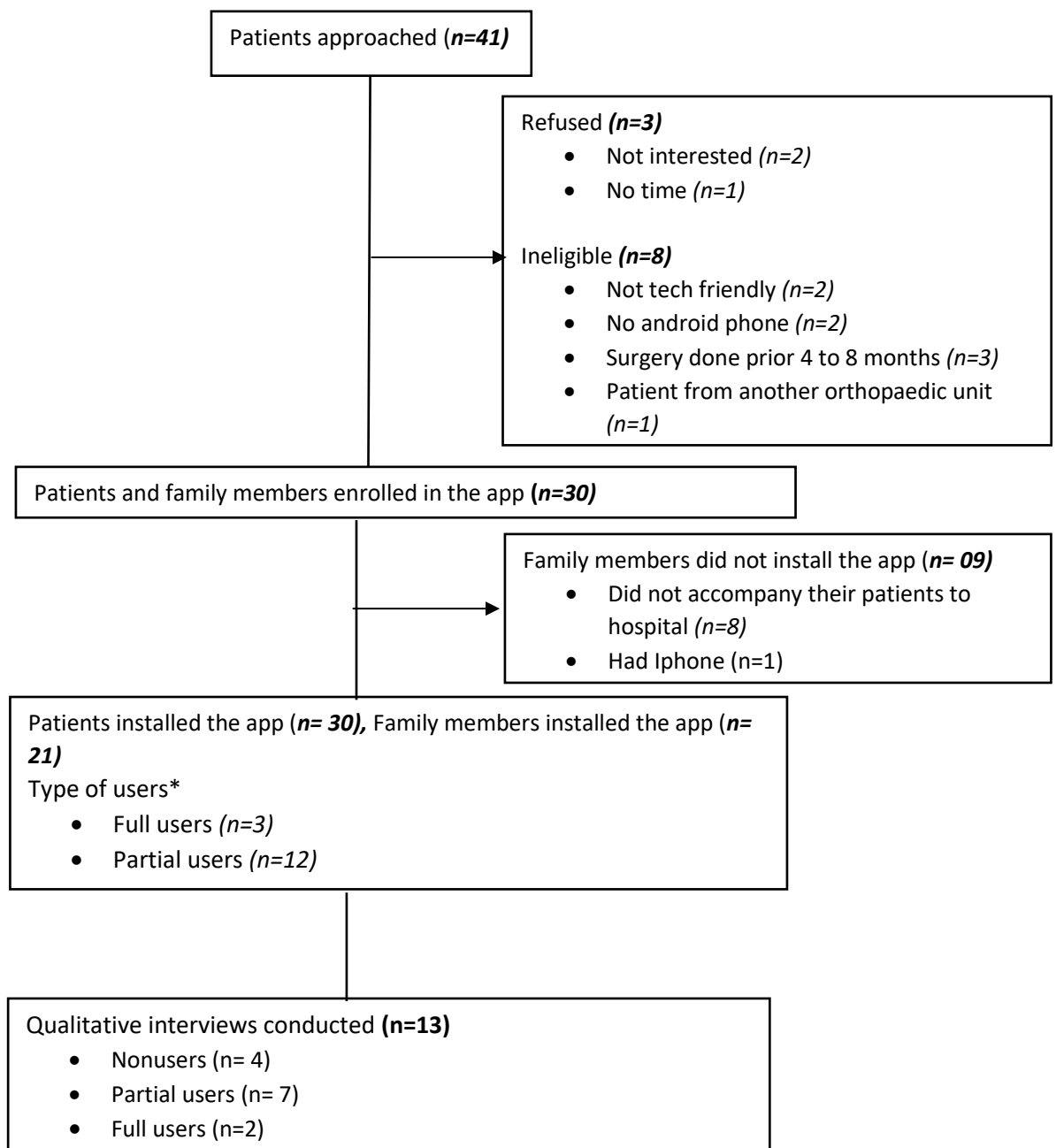
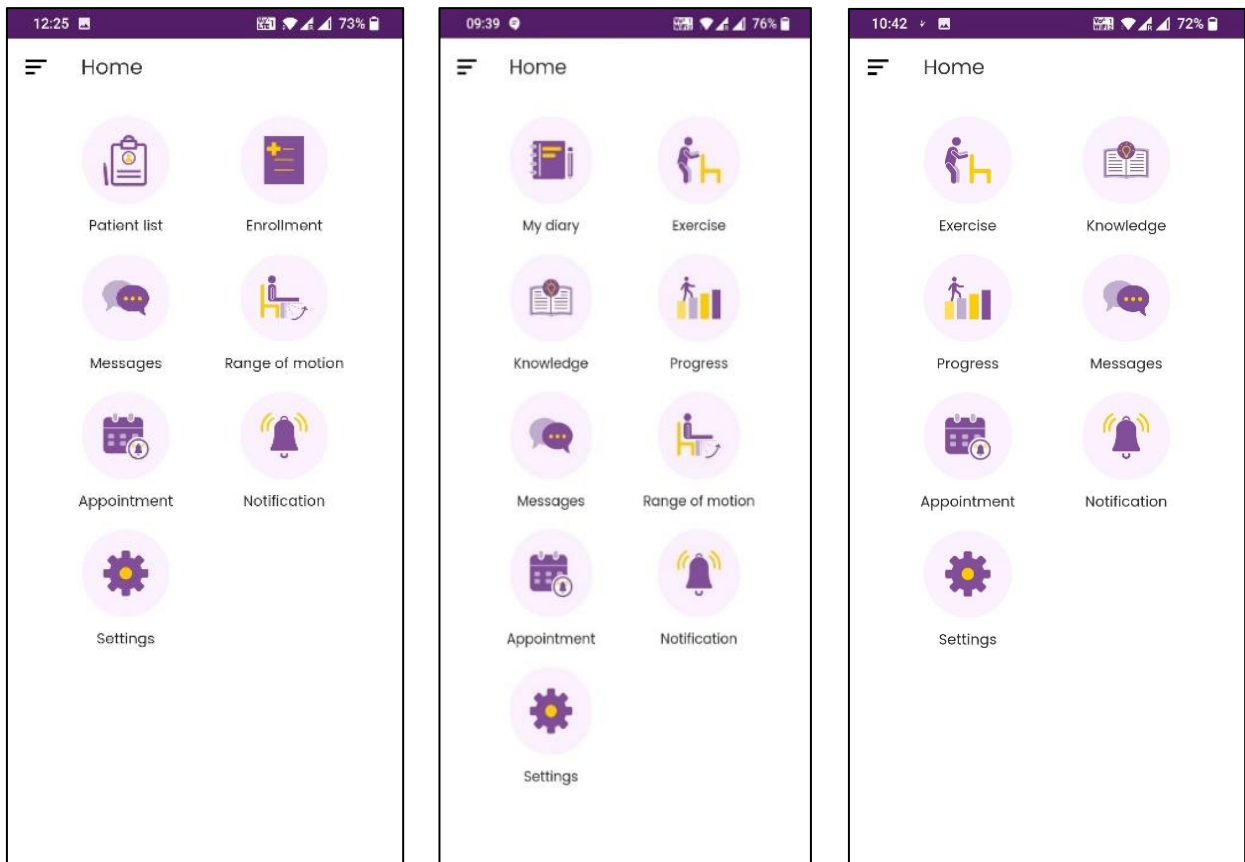


Figure 4-STROBE flowchart for the pilot study



\* Users who used  $\geq 5$  features out of 8 were categorised as full users while those who used  $\geq 1$  but less than 5 were categorised as partial users and those who did not use any feature were categorised as non-users.

Figure 5-Home screen of TReAT app



**A Healthcare provider**

**B Patient**

**C Family member**

Legend-The patient can access exercise repository, information e-booklet, my diary, measurement of ROM, progress, messaging, and appointment notification. The family member will have access to all the features except “my diary” and ROM function. The HCP can enrol patients, view patient list, measure knee ROM, and receive notifications. For each patient, HCP can view their history and progress via graphs, assign exercises via therapy plan, send, and receive messages, and fix appointment for video consultation.