Research Paper

# Telerehabilitation in Promoting Home-based Upper Extremity Exercises Among Stroke Survivors: A Pilot Study

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## ABSTRACT

**Objectives:** Stroke is a major cause of disability in adults, necessitating consistent patient-therapist interactions and diligent adherence to home-based rehabilitation programs to achieve substantial functional recovery. This study assessed audio-based telerehabilitation's (TR) preliminary effect and feasibility in promoting home-based upper extremity exercises among stroke survivors.

**Methods:** A 4-week parallel two-arm pilot study design was employed. Fourteen stroke survivors (seven each in the experimental and control groups) were recruited. Individuals in the control group received standard care consisting of visits to physiotherapy outpatient clinics, while the intervention group received standard care in addition to audio-based TR. The independent t-test and chi-square test were used to analyze differences in the clinical and sociodemographic data. The independent t-test was used to measure the treatment effect on the upper limb motor function (Fugl-Meyer upper extremity [FMA-UE] and Wolf motor function test [WMFT]), quality of life (QOL) (the World Health Organization (WHO) QOL brief, [WHOQOL-BREF]), and activities of daily living (Barthel index [BI]).

**Results:** The overall Mean±SD age of the participants is 50±8.2 years. The FMA-UE and WMFT scores changed from 17.57 to 25.86 (P=0.02) and 28.14 to 43.71 (P=0.03). No significant improvements in physical health, psychological, and social relationships domains of WHOQOL-BREF were recorded after the intervention. However, the environmental domain showed significant improvement (P=0.001). Scores of BI did not change significantly (P=0.49).

**Discussion:** The findings of this study provided preliminary evidence to support the feasibility and benefits of audio-based TR in promoting functional regain after the stroke. However, further studies with a robust design are needed to validate the reported effectiveness.

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## Highlights

- Consistent patient-therapist interaction and diligent adherence to home rehabilitation programs are required to achieve substantial functional recovery in stroke patients.

- Audio-based telerehabilitation (TR) can provide a cheap and efficient means to provide care to stroke patients, especially in resource-poor settings.

- Audio-based TR has shown significant promise in improving upper limb functional regain and user satisfaction with quality of care.

- Further investigations are required to establish the benefits of audio-based TR among stroke survivors.

## Plain Language Summary

Stroke causes disabilities that prevent individuals from carrying out their usual life activities. To help the individual regain their activity level, adequate contact with healthcare providers like physiotherapists is required. However, in events like the recent COVID-19 pandemic, it was difficult to establish such contact. We examined the feasibility and potential benefit of providing care remotely using audio messages via telephone calls. Our study showed that providing such kind of care was feasible, and the intervention group showed improvement in their arm and hand functions. Thus, we recommend that more studies be carried out to establish the benefits of this remote rehabilitation care delivery. We also recommend that such care be considered to improve access to rehabilitation services, especially in resource-poor settings.

## Introduction

Stroke ranks as a prominent contributor to global disability [1]. Worldwide, around 15 million individuals experience a stroke annually, leading to nearly 6 million fatalities due to direct effects or other complications of the stroke [2-4]. Thus, stroke continues to be a significant factor contributing to global mortality and morbidity [5]. The most common deficit after stroke is seen in the motor system, affecting more than 80% of patients [6]. Only a small number of patients achieve complete recovery from upper limb paralysis following a stroke. At the same time, the majority demonstrate persistent impairments, leading to limitations in activities, restrictions, and participation and decreased life satisfaction, quality of life (QOL), and overall welfare [7, 8].

In most developing countries that lack functional community rehabilitation services, a continuous hospital visit is required for therapeutic services in the rehabilitation of post-stroke patients, especially physiotherapy and occupational therapy for functional recovery. Many outpatients do not receive adequate treatment due to barriers such as problems with commuting, dependence on caregivers, limited outpatient services, poor social support systems, and limited finances and health insurance coverage [9, 10]. It is crucial to continue intensive physiotherapy to improve the upper extremity function after hospitalization [11, 12]. Stroke survivors could benefit from a system that allows health professionals to provide rehabilitation services from a remote location. Moreover, the COVID-19 pandemic left many post-stroke survivors without adequate rehabilitation services due to a shortage of staff and measures to curtail the spread of the disease, among other reasons [13]. The high burden of stroke and inadequate rehabilitation services prompt the need to develop and evaluate new strategies, such as the use of telerehabilitation (TR) [14].

TR refers to the delivery of health services via electronic communication (websites, telephone, mobile apps) geared towards enhancing an individual's health, offering education and services, and providing equal access to geographically remote patients who are physically and economically disadvantaged [9]. Existing TR studies indicate that individuals diagnosed with stroke who received their rehabilitation using a smartphone and or videoconferencing show an equal or even better improvement in their health status compared to those who received only usual care [15-17]. A recent study consistently indicated significant improvement in upper limb function due to intensive exercise programs delivered via TR [18]. Studies have also shown positive

outcomes and high patient satisfaction with TR across various healthcare conditions in developed countries [19-22]. Further, evidence has demonstrated that TR is safe and feasible among community-dwelling persons with stroke [23-25].

Most of the available evidence on the utility and feasibility of TR was reported from developed countries that have high technological advancement and may not be extrapolated to resource-poor settings like Nigeria. Despite the potential benefits of TR, there is a shortage of evidence on its utility and acceptability in Nigeria. Thus, this study aimed to provide evidence on the effectiveness and feasibility of TR in promoting home-based upper extremity exercises among stroke survivors in Nigeria.

## Materials and Methods

### Study design

This research employed a parallel two-arm design with blinded outcome assessors. All the study participants duly signed the informed consent form, and all research procedures adhered to the principles outlined in the Declaration of Helsinki [26, 27].

### Participants and recruitment

Participants were stroke survivors from outpatient physiotherapy clinics in Nigeria. The inclusion criteria were as follows: An episode of a cerebrovascular accident leading to one-sided hemiplegia or hemiparesis, age range between 40 to 65 years on the day of data collection, a stroke of ≥6 months, stable cognitive functioning (Montreal cognitive assessment [MoCA] ≥26 points) [28], and stable clinical condition [29]. The exclusion criteria were as follows: Cognitive impairment such as apraxia, neglect and language disturbances interfering with verbal comprehension, disturbed unaffected upper limb function, medical complications, and other problems possibly contra-indicating self-directed exercise at home [30]. The sample size was estimated based on a study where 7 adults with stroke participated in home-based TR [19].

### Intervention (TR group)

Participants in the intervention group performed a 4-week rehabilitation program that was task-oriented, individually customized, and intensive. For each participant, a physiotherapist prescribed an individualized exercise program (home program) with appropriate mode, frequency, duration, and intensity (number of repetitions and challenges involved), depending on the traits of the participant's impairments noted at the initial assessments [31]. During the study, the rehabilitation of the participants progressed through an exercise encompassing fundamental elements of reaching, grasping, holding, and manipulation, advancing in difficulty levels. An assigned physiotherapist moderated the exercises via audio calls. Audio telephone calls were employed to address complaints and queries, excluding the review and adjustment of the exercise prescription. Adjustments to the exercises prescribed were done during the usual hospital visits (usual care). Physiotherapist-patient contact via TR services was limited to 3-5 times a week. Participants were required to engage in their exercise program by using any exercise devices prescribed in conjunction with the guidance from the information sheet outlining their personalized exercise regimen. The patients were asked to return to the hospital if adverse clinical events occurred at home during the exercises. Assistance was provided by the caregivers of participants requiring support with their home program. In addition to the TR, participants in the intervention group received standard care involving regular outpatient physiotherapy visits (Figure 1).

### Control group (standard care only)

Participants in the control group exclusively received standard care, consisting of usual hospital visits to physiotherapy outpatient clinics as needed and regular home programs without physiotherapists' contact via TR services.

### Outcome measures

#### Primary outcome

**Fugl-Meyer upper extremity motor assessment (FMA-UE)**

The FMA is an observer-administered tool comprising 5 domains: Motor function (upper and lower extremity sub-domains), balance, joint pain, joint range of motion, and sensory function [32]. The scoring is done using a 3-point ordinal scale [32]. FMA-UE subscore for the upper arm is 36. The minimal clinically significant difference of the FMA-UE is 5.6 [33]. The FMA is psychometrically sound, with excellent scores for internal consistency (Cronbach α=0.94 to 0.98) [32]. The FMA exhibited a notable ceiling effect, with over 44.4% of subjects attaining the highest score. Additionally, the FMA demonstrates low to moderate validity (The Spearman rho ranging from 0.29 to 0.53) and low to moderate responsiveness (standardized response mean ranging from 0.27 to 0.67) [33].

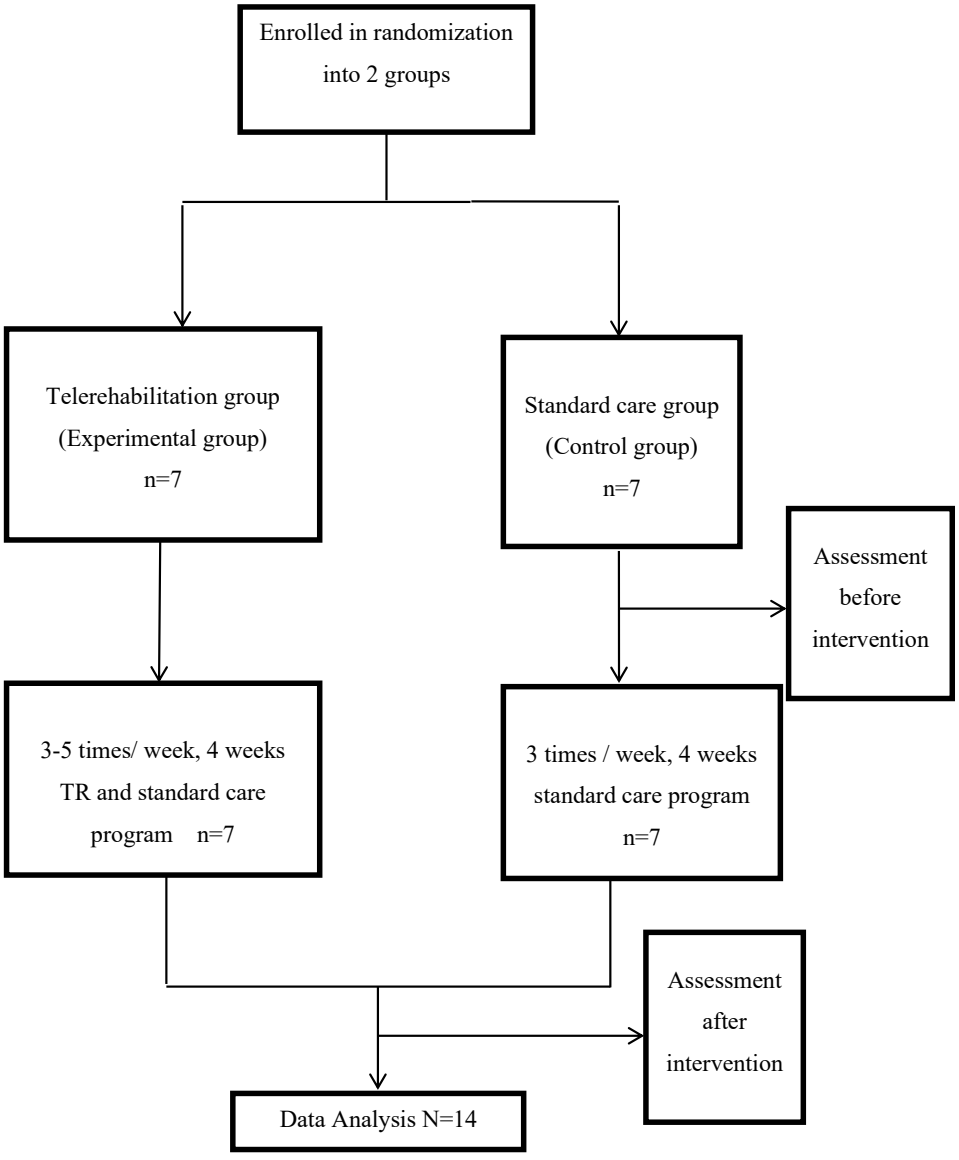




**Figure 1.** Study flow diagram

### Wolf motor function test (WMFT)

The Wolf motor function test (WMFT) represents a numerical measure of upper extremity function and motor deficiency in individuals affected by stroke or traumatic brain injury [34]. It consists of three parts (time, functional ability, and strength), including 15 functional-based tasks and two strength-based tasks. The WMFT time allows 120 seconds per task. It uses a 6-point ordinal scale of 0 to 5, with a maximum of 75 scores, where lower scores indicate a lower functioning level [35]. The inter-rater reliability of WMFT is excellent, with a score of 0.97. Additionally, the internal consistency measured by Cronbach α is high at 0.92. Furthermore, the stability of the WMFT is also deemed excellent [34].

## Secondary outcome

### World Health Organization (WHO) quality of life BREF (WHOQOL-BREF)

The WHOQOL-BREF is commonly used to measure the QOL in healthy and diseased populations [36] with 26 items [37]. Items number one and two ask about general health and overall QOL, whereas the remaining 24 questions that follow are categorized based on QOL domains [38]: Physical health, psychological, social rela-

tionship, and environment [39]. Each question is scored using a 5-point Likert scale, and domain scores are then converted to a scale of 0-100 points [37]. A score of 100 indicates better QOL, while 0 indicates a low QOL based on the scoring guideline [40]. WHQOL-BREF has shown moderate to high internal consistency as indicated by Cronbach α, ranging from 0.66 to 0.80, and excellent constructs validity (r=0.92) when correlated with scores from WHOQOL-100 [38].

### Barthel index (BI)

Barthel index (BI) is a commonly employed standardized tool by clinicians and researchers to evaluate disability in activities of daily living (ADL). It encompasses basic daily living (ADL) activities such as feeding, grooming, bathing, dressing, bowel and bladder care, toilet use, ambulation, transfers, and stair climbing. The total score on the BI spans from 0 to 20, with elevated scores indicating greater levels of functionality [41]. The BI is psychometrically sound among raters (kappa value range: 0.53-0.94, ICC=0.94) and has strong internal consistency (alpha=0.89 to 0.90). ADL was measured at baseline and four weeks [41].

## Feasibility

### Adherence

The patient's adherence was assessed by monitoring the frequency of calls made to them 3 to 5 times per week. These calls allowed tracking of the patient's attendance at each single session.

### Acceptability

Acceptability of the intervention was measured using a logbook to monitor adherence (acceptability). The TR group was asked to tick the logbook after each treatment session following the phone call.

### Satisfaction

The satisfaction of the intervention was evaluated subjectively using closed-ended questions. At the end of the fourth week during the data collection, stroke survivors were inquired about their contentment with the intervention received at the physiotherapy clinic with a yes and no answer.

### Procedure

Physiotherapists at the recruitment sites screened the patients for eligibility. The eligible patients were duly informed of the study rationale and procedure and were enlightened about the aim of the research. The patients provided written informed consent, and their confidentiality was guaranteed. Concealment of allocation was achieved using numbered, sealed, and opaque envelopes during the group allocation. This process resulted in allocating the participants into the intervention (TR+standard care) and control (standard care only) groups. The research member involved in the randomization process did not participate in administering the interventions and assessment process. Blinding was not possible in the study due to the nature of the intervention, making the researchers and participants fully aware of their assigned treatment groups. Two blinded outcome assessors conducted the baseline evaluation, which consisted of demographic characteristics (age, gender, educational level) and clinical variables (laterality, type, duration of stroke, and cognitive status). The outcomes were motor impairment, motor function, QoL, and ADLs, which were assessed using the FMA-UE, WMFT, WHOQOL-BREF, and BI, respectively. The two blinded outcome assessors reassessed the participants 4 weeks after completion of the intervention course using the same outcome measures.

### Data analysis

The statistical analysis was performed using SPSS software, version 20 (SPSS Inc., Chicago, IL, USA), using a variety of tests as appropriate. Demographic characteristics of the participants (age, gender, type of stroke, affected side, level of education, and time since stroke) were summarized using descriptive statistics. To ensure homogeneity among the groups at baseline, independent t-test and chi-square test were used to analyze differences in the clinical and sociodemographic data among the two groups. An independent t-test was used to measure the effect of the treatment on upper limb function, QOL, and ADL. A significance level of $P<0.05$ was employed to denote statistical significance. The feasibility analysis involves examining several factors, including assessing the frequency of logbook entries, tallying the responses to close-ended questions, distinguishing between 'yes' and 'no' answers, and quantifying and analyzing the number of responsive phone calls made to stroke survivors. This information was used to calculate the corresponding percentages.

# Results

## Demographics of participants

Fourteen stroke survivors (10 males) with a mean (SD) age of 50 (8.2) years participated in the study. Seven par-

ticipants were randomized to the intervention (5 males) and 7 to the usual care (5 males) group. Both groups were comparable in their ages at baseline (P=0.09). Baseline comparison revealed that no difference was observed between the groups regarding the educational level, time since stroke, and paretic side (P> 0.05). The majority of the participants had ischemic stroke, which accounts for 71.4% of the TR group and 85.7% in the standard care (Table 1). No adverse events were reported by any participant during the study.

### Effect of TR on upper limb function assessed using FMA–UE

The mean FMA-UE of the participants in the two study groups was not significantly different at baseline (P=0.86) but showed significant (P=0.02) differences after the TR intervention, with the TR+standard care showing greater change (17.57 to 25.86) relative to the baseline, compared to the control group (16.86 to 15.86) (Table 2).

### Effect of TR on upper limb function assessed using WMFT

The mean WMFT of the participants in the two study groups was not significantly different at baseline (P=0.32) but showed significant (P=0.03) differences after the TR intervention, with the TR+standard care showing greater change (28.14 to 43.71) relative to the baseline, compared to the control group (19.00 to 21.29) (Table 2).

### Effect of TR on QOL

The mean WHOQOL environment, WHOQOL physical health, WHOQOL psychological health, and WHOQOL social relationship of the participants in the two study groups was not significantly different at baseline. However, the WHOQOL environment showed significant (P=0.001) differences after the TR intervention, with the TR+standard care showing greater change (62.57±13.43) relative to the baseline, compared to the control group (69.00±7.75) (Table 2).

**Table 1.** Sociodemographic characteristics of the participants

| Variables | | Mean±SD/No. (%) | | Difference |
|---|---|---|---|---|
| | | Intervention | Control | |
| Age (y) | | 58±5.83 | 50.71±8.62 | t=1.85, P=0.09 |
| Gender | Female | 2(28.6) | 2(28.6) | |
| | Male | 5(71.4) | 5(71.4) | |
| Educational Level | No school | 1(14.3) | 2(28.6) | |
| | Islamic school | 2(28.6) | 1(14.6) | |
| | Secondary school | 1(14.3) | 2(28.6) | |
| | Diploma | 2(28.6) | 2(28.6) | |
| | Degree | 1(14.3) | 0 | |
| Affected side | Right | 3(42.9) | 2(28.6) | |
| | Left | 4(57.1) | 5(71.4) | |
| | Time since stroke | 37.7±38.27 | 32.71±27.02 | t=0.28, P=0.78 |
| Type of stroke | Ischemic | 5(71.4) | 6(85.7) | |
| | Hemorrhagic | 2(28.5) | 1(14.28) | |
| | MOCA pre-intervention | 26.0±0.00 | 26.0±0.00 | |
| | MOCA post-intervention | 26.0±0.00 | 26.0±0.00 | |

MOCA: Montreal cognitive assessment.

**Table 2.** Changes in outcome measures before and after the intervention

| Outcomes | Mean±SD | | Difference |
|---|---|---|---|
| | Intervention | Control | |
| FM-UE, pre-intervention | 17.57±7.79 | 16.86±6.94 | t=0.18, P=0.86 |
| FM-UE, post-intervention | 25.86±7.36 | 15.86±6.47 | t=2.7, P=0.02* |
| WMFT, pre-intervention | 28.14±15.00 | 19.00±17.93 | t=1.04, P=0.32 |
| WMFT, post-intervention | 43.71±17.27 | 21.29±16.30 | t=2.50, P=0.03* |
| WHOQOL-PH, pre-intervention | 59.14±5.21 | 51.00±7.55 | t=2.35, P=0.04 |
| WHOQOL-PH, post-intervention | 60.86±5.01 | 55.43±6.78 | t=1.7, P=0.11 |
| WHOQOL-PSYCO, pre-intervention | 64.29±12.83 | 50.14±8.84 | t=2.40, P=0.03 |
| WHOQOL-PSYCO, post-intervention | 64.43±7.07 | 50.00±10.31 | t=3.05, P=0.11 |
| WHOQOL-SR, pre-intervention | 63.29±17.17 | 41.00±20.01 | t=2.24, P=0.05 |
| WHOQOL-SR, post-intervention | 64.29±14.23 | 51.00±17.07 | t=1.58, P=0.14 |
| WHOQOL-Env, pre-intervention | 62.57±13.43 | 51.14±12.12 | t=1.67, P=0.12 |
| WHOQOL-Env, post-intervention | 69.00±7.75 | 51.00±6.71 | t=4.65, P=0.001* |
| Barthel-index, pre-intervention | 15.00±3.96 | 15.86±2.27 | t=0.50, P=0.63 |
| Barthel-index, post-intervention | 17.29±2.87 | 16.29±2.36 | t=0.71, P=0.49 |

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Abbreviations: FM-UE: Fugl-Meyer upper extremity; WMFT: Wolf motor function test; WHOQOL-PH: World health quality of life physical health; WHOQOL-PSYCO: World health quality of life psychological health; WHOQOL-SR: World health quality of life social relationship; WHOQOL-Env: World health quality of life environmental health.

*Statistically significant (P<0.05).

## Effect of TR on ADL

The mean BI of the participants in the two study groups was not significantly different at baseline (P=0.63); it also showed no significant (P=0.49) difference after the TR intervention (Table 2).

## Feasibility

### Adherence

No participant withdrew from the TR intervention group. Thus, we recorded high adherence to the intervention (100%).

### Acceptability

TR was acceptable to the participants; they practiced their exercise program as prescribed, indicating high acceptability (100%).

### Satisfaction

The TR group participants reported higher satisfaction with the intervention compared to those in the usual care group (100%).

## Discussion

This study aimed to find preliminary evidence on the feasibility and influence of audio-based TR in promoting home-based upper extremity exercises among stroke patients. Findings from this study show that a 4-week TR intervention is feasible and effective, producing substantial gains in arm motor function and QOL among stroke patients.

The primary functional outcomes, FMA-UE and WMFT, improved significantly after the intervention, possibly due to improved brain plasticity and the restoration of functional capabilities among the participants [22, 42]. There was a substantial improvement in the environment domain of the WHOQOL-BREF, which could be attributed to the influence of the environment

where the patients received the TR treatment [36]. However, there was no significant improvement in physical health, psychological, and social relationships domains of WHOQOL-BREF following the 4 weeks intervention [36]. Multiple studies have shown that familiar environments can improve rehabilitation outcomes by promoting meaningful task-specific training, providing a sense of control, increasing confidence, and enhancing skills [43]. Data from this study showed no evidence of a beneficial effect of TR when compared with usual care on ADLs. Presumably, the patients had already learned to independently manage their daily needs without using their affected arm [44]. The positive intervention changes observed in motor function and QOL in the present study are good indicators; however, only a randomized trial can provide substantial evidence of the effectiveness of the TR intervention [45, 46]. The patients expressed satisfaction with the intervention and were motivated to remain in the program because the intervention resulted in positive outcomes such as improved physical functioning and QoL (Q). The study findings indicate that using TR potentially enhances motor function among stroke survivors [47].

The result of this study shows that the motor function of patients in the TR group was significantly better than that of patients in the standard care group. This finding is consistent with the previous findings reported by Cramer and colleagues, who observed significant improvements in physical function in post-stroke patients who participated in a video-based TR [48]. Similarly, TR was shown to be effective in promoting motor function restoration in stroke patients' upper extremities [49]. A notable improvement in physical performance measured with the FMA-UE was reported [49].

On the other hand, the present study shows no significant difference in ADLs between the TR and standard care group. These findings align with the study outcomes by Chumbler et al. and Forducey et al., who assessed independence in ADLs after TR intervention [50, 51]. Both studies observed no notable difference between the intervention and control groups in ADLs [50, 51]. Moreover, this study documented a substantial enhancement in the environmental domain of QOL. However, this finding is partly consistent with the literature, indicating that TR significantly improves all domains of QOL measured with WHOQOL-BREF [52].

Furthermore, previous studies have reported that TR was feasible and well-received by stroke patients [49, 52, 53]. The findings of the present study corroborate the feasibility of TR, as reported in the literature. There is a shortage of studies that focus specifically on the use of audio-based TR in promoting upper limb motor function among stroke patients, thus limiting comparison of the findings from the present study.

This study is not without limitations. We employed a feasibility design with an insufficient sample size, thus limiting the applicability of the findings. Hence, studies with a more robust design and a larger sample size are recommended. Although the study primarily concentrated on the upper extremity of the post-stroke patient, several other areas of impairment could benefit from TR, such as deficits in the lower limb. The majority of the participants are middle-aged males with ischemic stroke; thus, the findings of the study should be interpreted with caution. Hence, future studies with representative samples are warranted. The TR mode of intervention would indisputably reduce clinical visits and waiting time. On the other hand, we believe TR may not be appropriate for individuals with severe impairments due to potential hindrances caused by worsened disabilities, such as spasticity and contracture, that may negatively affect motor skills [53].

However, the study has some strengths, as follows. The intervention facilitated two-way communication between physiotherapists and patients, thus providing a means for proper communication. The assessors were blinded, and the participants were randomly assigned to minimize bias and improve the study's validity. The audio-based TR contributes to a notable enhancement in functioning during the early stage of recovery. The TR recipients found it acceptable, completing almost 100% of therapy sessions with no reports of serious adverse events related to treatment.

## Conclusion

This study revealed that TR intervention is feasible and shows significant promise in enhancing upper limb motor function and QOL among adult stroke survivors. Therefore, TR can be considered a complementary intervention to the conventional in-person approach to upper extremity rehabilitation among stroke patients and promote access and affordability of rehabilitation services. Further, this study suggests that using TR to deliver upper limb rehabilitation could be superior to conventional methods in improving motor function and QOL among stroke patients. However, further studies in the form of randomized controlled trials with larger representative samples are warranted to validate the effectiveness of the TR intervention.

## Ethical Considerations

### Compliance with ethical guidelines

The Ethics Committee of the Ministry of Health and Human Services (Code: MOH/GEN/747/001/01) granted the study's approval. The study was registered at Pan African Clinical Trials (Code: PACTR202301605291913).

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### Authors' contributions

Conceptualization and Methodology: Hafsat Maina Ali, Surajo Kamilu Sulaiman, and Umar Muhammad Bello; Supervision and data analysis: Surajo Kamilu Sulaiman and Umar Muhammad Bello; Data collection: Abdullahi Salisu Muhammad, Fatima Mahmud Ado, Hassan Ali Maina, Hussaina Abubakar Jalo, Mohammed Usman Ali, Ismail Muhammad Bello, and Halima Maina; Writing the original draft: Hafsat Maina Ali, Abdullahi Salisu Muhammad, Fatima Mahmud Ado, Hassan Ali Maina, Hussaina Abubakar Jalo, Mohammed Usman Ali, Ismail Muhammad Bello, and Halima Maina; Review and editing: Surajo Kamilu Sulaiman and Umar Muhammad Bello.

### Conflict of interest

The authors declared no conflict of interest.

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