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High acceptability, convenience and reduced carbon emissions of tele-neurology outpatient services at a regional referral centre in Kenya

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ABSTRACT

Background: There is severe shortage of neurologists in sub-Saharan Africa. Tele-neurology consultations (TNC) can bridge this service gap, but there is very little published evidence on TNC in our setting, which we addressed through our study.

Methods: We prospectively enrolled patients at our neurology outpatients from October 2020 to October 2021. We administered a post-TNC questionnaire which captured satisfaction/acceptability using Likert scales. A subgroup of participants who also did in-person consultations (IPC) were additionally administered post-IPC questionnaires. Statistical comparisons were made using the paired student *t*-test, and descriptive data expressed as median (inter-quartile range).

Results: From 219 enrolled patients, 66.7% participants responded: 74.0% had both IPC and TNC; 63.0% were female; age was 40.9 (30.6–55.2) years; and 2.7% were from neighbouring countries. The commonest presentations were headache (30.8%), seizures (26.0%) and neurodegenerative disorders (15.1%). For TNC, >90% found it: (i) as comfortable as IPC ($p = 0.35$); (ii) didn't violate their privacy; (iii) saved time [3.0 (2.0–4.0) hours], travel [11.0 (7.2–21.1) km] and cost [$9.09 (4.55–18.18)]; and (iv) addressed their concerns satisfactorily such that they would use TNC again. Conversely, 15.1% didn't agree with TNC being as effective as IPC, and felt the neurologist did not satisfactorily identify all of their health problems ($p = 0.03$). In total, our TNC service saved our patients $6167, 1143 h, and 25,506 km of travel, translating to 3.5 t (equivalent to 21 newly-planted trees) of carbon dioxide emissions.

Conclusions: Our study demonstrates that TNC is an acceptable, efficient, effective, and environmentally-sustainable care delivery model.

1. Introduction

Neurological disorders are amongst the leading cause of morbidity and mortality worldwide [1]. Sub-Saharan Africa (SSA) has 12% of the world's population but disproportionately two-thirds of the global neurological disease burden, and together with a severe shortage of neurology healthcare workers on the continent [2], these factors are significant barriers to providing adequate neurologic healthcare in SSA.

High-income countries who have encountered some of these barriers – e.g. providing patients in remote areas with good care – have demonstrated tele-medicine as an effective solution without compromising safety and continuity of care [3]. Telemedicine has additionally provided opportunities to significantly reduce the carbon footprint of healthcare [4], which, globally, is needed now more than ever [5]. In SSA, however, telemedicine has had little uptake due to numerous infrastructural challenges [6].

Tele-neurology, i.e. telemedicine for neurological conditions, has also been developed to provide successful care for headaches, epilepsy, stroke, dementia and many other chronic neurological conditions [7], leading to the development of guidelines to deliver the service effectively [8], as well as questionnaires to measure patient and/or provider satisfaction [9]. Even before the onset of the COVID-19 pandemic, teleneurology has been demonstrated to be effective in delivering care, and the longer the service is used, more practitioners and patients enroll onto the service and almost use it as a default [10].

Just like telemedicine, the utilization of teleneurology in SSA has remained sparse and therefore lacks evidence to allow wider application in the region [11,12]. However, the COVID-19 pandemic abruptly

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necessitated innovation in delivering healthcare remotely across the world, and international guidelines were instituted to facilitate this safely for patients with neurological conditions [13,14]. The need for sudden implementation of tele-neurology consultations (TNC) early on in the pandemic was met with just as steep a rise in resilience from patients and neurologists so that care could continue to be provided remotely [15]. Examination of the patient's neurological system during TNC has had to be done by an accompanying healthcare provider in the patient's home whilst video-conferencing with the consulting neurologist [16], and such remote examinations have become increasingly acceptable for neurologists [17].

It became clear that, regardless of the healthcare setting, TNC encountered infrastructural barriers such as poor internet connectivity and unavailability of smartphones for a segment of the patient populations e.g. due to technophobia, or living in very remote areas [18,19]. Nevertheless, even outside developed countries, patient satisfaction (e.g. Saudia Arabia [20] and Mexico [21]) and neurologists' comfort [22] with TNC has been shown to become more and more acceptable. The most efficacious delivery of tele-neurology services in SSA during the pandemic was in Zambia, where patients and providers showed very high satisfaction with the service [23]. However, this important study had some limitations: questionnaires were administered 3–4 months post-hoc; there were a relatively low proportion of respondents, who were mostly caregivers rather than patients; there was no comparison to in-person consultations (IPC); and there was no objective measure of convenience in terms of time, cost and travel savings to the patient.

Soon after the onset of the pandemic in Kenya, we successfully piloted a TNC service at our institution [24]. In our ensuing larger prospective study, we sought to address the gaps in knowledge about the usability of TNC in SSA by measuring patient satisfaction as well as convenience with TNC, and compared these with IPC in a subgroup of participants. Additionally, we set out to measure the positive environmental impact of delivering care through our TNC model in terms of carbon dioxide emissions saved through reduction in travel for IPC.

2. Material and methods

2.1. Study design

This was a descriptive prospective non-randomised cross-sectional study, with a nested TNC-IPC case-crossover subgroup.

2.2. Study site and participants

We recruited patients who were referred to the principal investigator (PI: author DSS, consulting neurologist) at the neurology outpatients at the Aga Khan University Hospital, Nairobi, from October 2020 to October 2021. Inclusion criteria were age ≥ 18 years, and participants or their registered next of kin to have the cognitive capacity to consent.

2.3. Study materials

With the author's consent, we adopted 15 questions from a pre-validated tele-neurology satisfaction questionnaire [9] for our post-TNC survey. We used a further subgroup of these selected questions for the post-IPC questionnaire. For both IPC and TNC participants we additionally captured the primary neurological diagnosis as ascertained by the PI.

We also captured convenience markers in the form of expense that would have been incurred (for pure TNC), or had been incurred (for IPC), by the patient in terms of time, travel (including mode of transport), and monetary cost if they had had IPC instead of TNC. The questionnaires are available in the supplementary material.

2.4. Study flow

Fig. 1 summarises the patient recruitment process. Patients were either new consults (never seen the neurologist before) or follow-ups. Triaging happened the day before the clinic using the outpatient booking list generated by hospital's default electronic system. New patients were triaged by telephone by the PI for any red flags, as per our institution-specific guidelines that were adapted from the British and American guidelines for tele-neurology [13,14] (see supplementary material for our internal guideline). Those who triggered were given IPC, and those deemed safe were given TNC. Stable follow-up patients were triaged by the nurse and if deemed safe and the patient agreed, booked for TNC, otherwise the case was discussed with the PI and the patient then allocated IPC or TNC.

Patients (or caregivers if patients did not have the capacity) were informed of the study by the PI at end of each consultation. If they were interested, their email addresses and contact telephone numbers held on the hospital system were confirmed and provided to the clinical research assistant (author FAY) for enrollment. The study information leaflet and consent form were held as electronic documents on REDCap® [25], and FAY would send them to the patient/caregiver within 48 h of the consultation. Patients/caregivers consented to the study by electronically signing the consent form via the link from REDCap®, after which FAY would send the electronic link(s) to the questionnaire(s) to the participant.

For each participant, if there was no questionnaire response within one week, FAY would follow up with a reminder telephone call and email. If there was still no response by the end of the second week post-consultation, FAY would repeat the follow up procedure for the last time before labelling the participant as a non-responder, and would then inform the PI.

2.5. Ethical considerations

We obtained approval from both our Institutional Ethics in Research Committee [reference 2020/IERC-96(v2)] and from the National Commission for Science, Technology and Innovation (NACOSTI) prior to conducting the study.

Patients/caregivers were given ample time to read the study information leaflet and could contact the PI or FAY if they had any queries or concerns.

Patient confidentiality was maintained during entire period of the study. Participants were allocated a study number once they enrolled on to the study. The PI kept a separate log on a Microsoft Excel sheet which linked the study number to the patient's unique hospital ID number only, in case a situation arose where there the original hospital records had to be reviewed e.g. for clarity on the diagnosis. This sheet was password-protected by the PI, and kept on the PI's institutional cloud storage that could only be accessed by the PI via two-factor authentication.

During the data analysis, if participants had inadvertently inserted any information in the free-text fields that could identify them and were not relevant to the study, the information was removed from the final dataset.

TNC was offered a telephone call from the hospital switchboard to the patient's mobile number. In some instances, if a video-conference was required, the TNC took place over a standard hospital-approved tele-conferencing platform (Zoom®) with all important privacy features pre-enabled, and video recordings disabled.

2.6. Data analysis

Categorical data was summarized as frequencies and percentages and continuous data as medians and interquartile ranges.

The options to answer each question in either questionnaire were on a five-point Likert scale, for which we respectively ascribed scores between 1 and 5 as follows: 'strongly disagree' = 1; 'disagree' = 2; 'neither

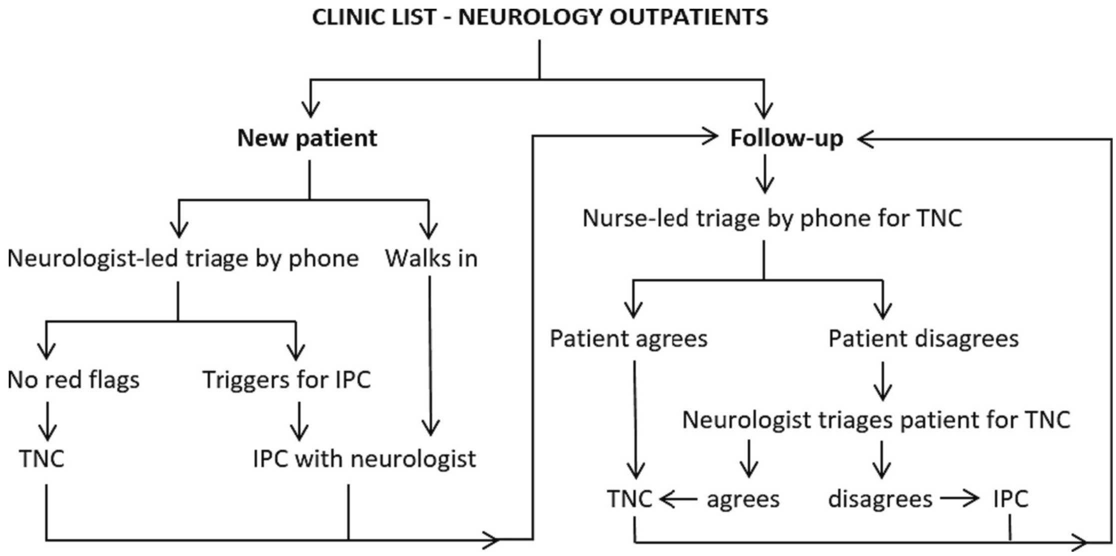

Fig. 1. Patient recruitment process. IPC: in-person consultation; TNC: tele-neurology consultation.

agree nor disagree' = 3; 'agree' = 4; and 'strongly agree' = 5. The 15-question post-TNC survey thus had a maximum score of 75 points, and we followed the satisfaction categorization as had been described by the questionnaire's author [9]: ≤15 = 'very low'; 15–30 = 'low'; 31–45 = 'moderate'; 46–60 = 'high'; and 61–75 = 'very high'.

Distances from each patient's nearest township to our hospital were calculated in km through Google Maps. Carbon footprint was calculated based on both the calculated distance and the patient's modality of transport using an online platform (https://www.carbonfootprint.com/) which has been reliably used in similar recent studies [26]. Costs given by the patient in the local currency (Kenyan Shillings, KES) are converted to US dollars ($) at a rate of KES 110 to $1, which was the average foreign exchange rate during the study period, as per a reliable online resource (https://www.exchangerates.org.uk/).

3. Results

We enrolled 219 patients, of whom 66.7% (146/219) filled out the questionnaires; the remainder were classified as non-responders. The demographic and clinical characteristics of the responders is summarized in Table 1. There were no significant differences in these parameters between TNC and IPC.

The results of the questionnaire surveys are summarized in Figs. 2 and 3, and Table 2. Of the 146 responders, 74.0% (108/146) had both TNC and IPC. Responses consisting of 'disagree' and 'strongly disagree' are shown combined as 'Disagree', and likewise responses consisting of 'agree' and 'strongly agree' are shown combined as 'Agree'. For Fig. 2, 'low' and 'very low', and 'high' and 'very high', categorizations are combined as 'Low' and 'High' respectively.

The results of the paired *t*-test when comparing TNC and IPC responses are also shown ($n = 108$). Some respondents did not complete all the questions in each questionnaire, and the total number of respondents for such questions when <146 are also clarified in the table.

Table 3 summarises the analysis of the convenience markers. Total distance calculated was for both to and from the hospital clinic. The modes of transport were required for carbon footprint analysis as each modality has a different rate of carbon dioxide (CO_2) emissions. The total carbon emissions saved was calculated as 3.5 t of CO_2 for this cohort of patients.

Table 1
Summary of demographic and clinical characteristics of 146 respondents. *Other diseases: multiple sclerosis, idiopathic intracranial hypertension, ataxia, Bell's palsy, functional neurological disorders, fibromyalgia, spinal disease and vertigo.

Demographic and Clinical Characteristics ($N = 146$)		n (%)
Gender	Male	54 (37.0)
	Female	92 (63.0)
Age (years)	Median [IQR]	40.9 [30.6, 55.2]
Country & county	Kenya	142 (97.3)
	Within Nairobi County	104 (71.2)
	Nairobi Metropolitan Area outside Nairobi County	24 (16.4)
	Other Counties	14 (9.6)
	Outside of Kenya	4 (2.7)
Clinical diagnoses	Primary headache disorders including migraine	41 (28.1)
	Epilepsy/transient loss of consciousness	38 (26.0)
	Neuropathy/neuromuscular	18 (12.3)
	Dementia/neurodegenerative	12 (8.2)
	Movement disorders including Parkinson's disease	11 (7.5)
	Stroke/cerebrovascular disease	6 (4.1)
	Other*	20 (13.7)

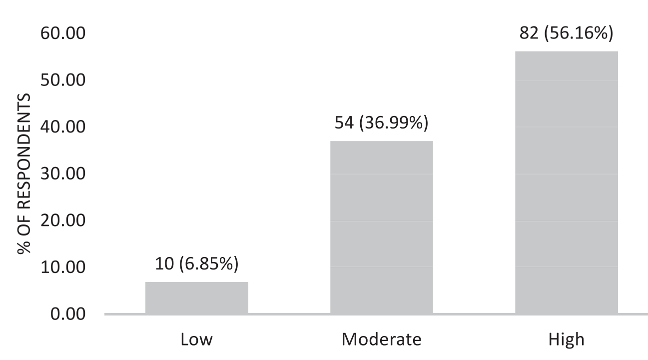

Fig. 2. Overall satisfaction from TNC (see text for details on details for categorization of responses into 'low', 'moderate' and 'high').

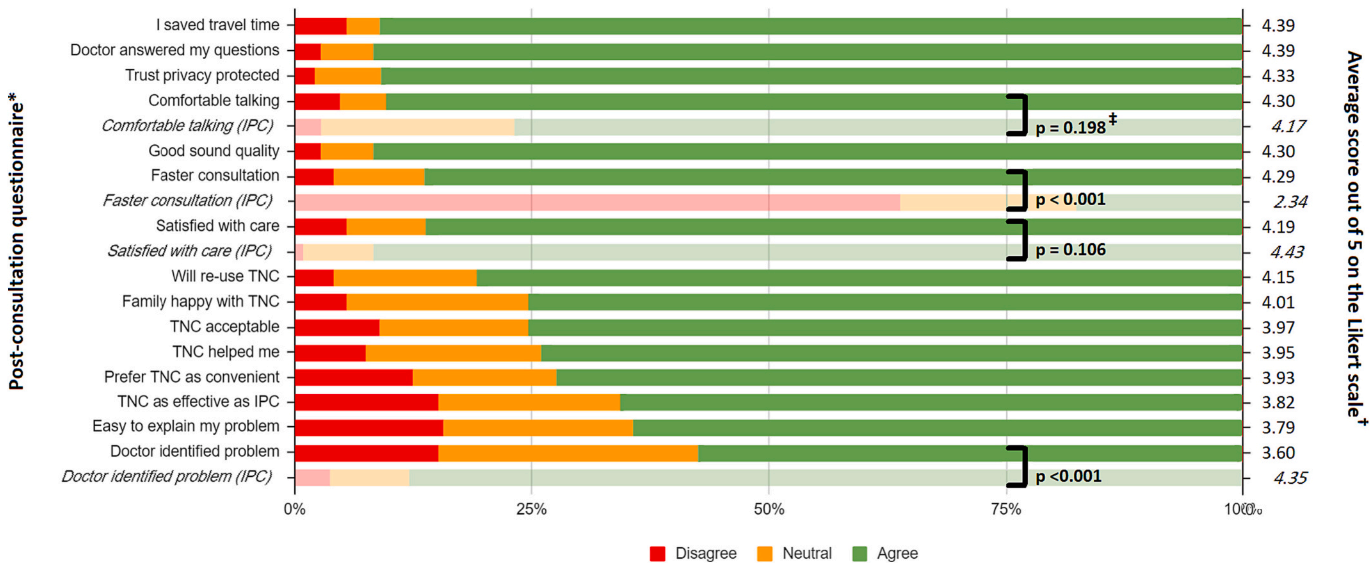

Fig. 3. Graphical summary of results of Table 2. Key for symbols: * *questions from survey have been truncated. All responses are for tele-neurology consultations (TNC); responses for in-person consultations (IPC; questions in italics) have been juxtaposed, as lighter colour shades, to the respective TNC question for comparison.*
† Denoted scores for responses (see text for interpretation of the numerical scores) from the Likert scale have been calculated as averages, with the maximum (denominator) value being 5. The average scores are shown here in descending order. IPC results are shown in italics.
‡ *p-values calculated using the paired student t-test for the four questions common between TNC and IPC questionnaires.*

Table 2
Results of the post-consultation surveys, with TNC-IPC statistical comparisons for those patients who had both consultations. **p*-value is from paired student *t*-test.

Questionnaire item	Post-TNC survey (n = 146)			Post-IPC survey (n = 108)			p-value*
	Disagree	Neutral	Agree	Disagree	Neutral	Agree	
I am satisfied with the care received (n = 145)	8 (5.5%)	12 (8.3%)	125 (86.2%)	1 (0.9%)	8 (7.4%)	99 (91.7%)	0.106
My family is satisfied with the care received in telemedicine	8 (5.5%)	28 (19.2%)	110 (75.3%)				
Telemedicine helps me know my state of health	11 (7.5%)	27 (18.5%)	108 (74.0%)				
I felt comfortable talking to my specialist doctor through a microphone / in person	7 (4.8%)	7 (4.8%)	132 (90.4%)	3 (2.8%)	22 (20.4%)	83 (76.9%)	0.198
Talking to my specialist was as effective as in person	22 (15.1%)	28 (19.2%)	96 (65.8%)				
It was easy for me to explain my health problem to the doctor	23 (15.8%)	29 (20.0%)	94 (64.4%)				
My specialist doctor has identified my health problem through the consultation	22 (15.1%)	40 (27.4%)	84 (57.5%)	4 (3.7%)	9 (8.3%)	95 (88.0%)	<0.001
The quality of sound were adequate to talk to my specialist doctor	4 (2.7%)	8 (5.5%)	134 (91.8%)				
The time with a specialist is faster with telemedicine / in-person	6 (4.1%)	14 (9.6%)	126 (86.3%)	69 (63.9%)	20 (18.5%)	19 (17.6%)	<0.001
I prefer telemedicine because it is easier than to go to the hospital (n = 145)	18 (12.4%)	22 (15.2%)	105 (72.4%)				
Telemedicine saves me time travelling to hospital or a specialist clinic	8 (5.5%)	5 (3.4%)	133 (91.1%)				
My specialist doctor was able to answer my questions through telemedicine (n = 145)	4 (2.8%)	8 (5.5%)	133 (91.7%)				
I find telemedicine an acceptable way to receive health-care services	13 (8.9%)	23 (15.8%)	110 (75.3%)				
I will use telemedicine services again	6 (4.1%)	22 (15.1%)	118 (80.8%)				
I trust that my personal information and privacy will be protected after my consultation by telemedicine (n = 143)	3 (2.1%)	10 (7.0%)	130 (90.9%)				

4. Discussion

4.1. Demographic and clinical characteristics

We had a much higher response rate from participants compared to other studies done in SSA [23]. The majority of responders were female, similar to other TNC studies [17,21] and to surveys in general [27], and similarly from the 35–45 years age group [17,21], which probably reflects the higher comfort with using information technology amongst the younger population in Kenya [28]. In contrast to the study from Mexico, our participants included both new and follow-up patients as opposed to follow-ups alone [21].

Table 3
summary of convenience markers.

Convenience Markers ($n = 146$)	Median [IQR]	Total
Time (that would have been) taken out of routine (hours)	3.0 [2.0–4.0]	1143
Distance to hospital (km)	11.0 [7.2–21.1]	25,506
Approximate travel cost undertaken/if was to travel ($)	9.09 [4.55–18.18]	6166.72
Mode of transport	n (%)	
Own vehicle/motorcycle	86 (58.9)	
Taxis (private, motorcycles, mobile phone apps e.g. Uber)	44 (30.1)	
Public transport	14 (9.6)	
Air transport	2 (1.4)	

The majority of patients had neurological conditions such as primary headache disorders and epilepsy, which usually do not warrant a full in-person physical examination, findings similar to those in Latin America [21,29]. The other diagnoses listed in Table 1 are similar to the profile of patients who accepted TNC in the Chilean as well as Zambian study [23] i.e. chronic patients with stroke, movement disorders and dementia. Also similar to the Zambian study, our study showed no significant difference in the demography or clinical characteristics of the patients who had TNC compared to IPC.

4.2. Patient satisfaction

In our study, the vast majority of patients (93.1%) and their families (75.3%) had overall satisfaction scores in the moderate, high or very high categories, which is similar to findings from the other studies on tele-neurology acceptability in developing countries [9,19–21,23]. Similarly, in our TNC-IPC comparison analysis, there was no significant difference in patients' satisfaction of either type of consultation, just as other studies have shown, and patients were just as comfortable talking to the neurologist over the phone as they were in person [21]. Patients also had high levels of confidence in their privacy being maintained (90.9%), similar to the study in Mexico [21].

Conversely, the highest dissatisfaction (15.8%) was on the ease of patients communicating their problems to the doctor via TNC, similar to the Chilean study [9]. This can partly be due to patients' unfamiliarity in using digital technologies and online platforms for TNC [19] or even lack of availability of good connectivity and appropriate TNC devices [18]. The most significant differences in patient satisfaction between TNC and IPC were for two main aspects:

(i) patients felt the neurologist identified their problem more in IPC compared to TNC. Indeed, the lowest aggregate scores for TNC satisfaction were on the relative easiness for the patient to express their problem, and for the patient to feel the neurologist had understood their complaint. The original survey done in Chile with the same tool demonstrated the lowest scores in these two same questions [9]. Despite high usage of telemedicine consultations, patients still prefer to "see" their doctors in the traditional sense i.e. in person, as the interaction is felt to be more in-depth and personal [30].

(ii) Patients felt TNC were more time-efficient compared to IPC ($p < 0.001$). Medical outpatients, especially in resource-limited settings, are notorious for patients being dissatisfied with the long waiting time to see the doctor [31] and the reasons are multi-factorial. TNC circumvents these delay factors by allowing patients to be consulted within a set clinic appointment slot, without the delays brought about by inefficient recording of vital signs, or patients disregarding the queue and arriving outside their allocated clinic appointment time.

4.3. Convenience and carbon footprint

The most unique findings of our study are the markers of convenience, which have not been measured objectively in other tele-neurology studies. Our patients who engaged with TNC saved a median of 3 h from their daily activity which would have been spent on travelling to hospital and waiting for IPC. This translates to significant economic savings, given the majority of our patients were of the working age group. Even after excluding the costs of flights for the two patients who would have had to fly in from neighbouring countries for IPC, our TNC service saved patients a median of $9.09 in transport costs, which is significant considering the average monthly salary in Nairobi is approximately $300 [32]. Putting these together, it is not surprising that most of our patients preferred TNC and would use it again, such as what participants in other studies also expressed [9,21,23].

The total travel distance saved was 25,506 km, with a median round-trip of 11 km per patient. This is much lower than what was found in a US study that had a large rural catchment area (average 382 km saved per visit) [10] probably due to the majority of our patients (87.6%) coming from within and around the Nairobi Metropolitan Area.

Our small study of 146 outpatients saved 3.5 t of CO_2 emissions, equivalent to planting 21 trees. Healthcare systems account for 4% of total greenhouse gas production and streamlining care systems through TNC are one example of reducing such emissions [33].

4.4. Study limitations

A full clinical consultation usually requires physical examination, which was not possible in our TNC service. Our triaging system with the study converted patients who required a physical exam to IPC. Whilst there is growing acceptability amongst neurologists to examine patients via TNC [17], it is not yet clear whether this translates safely to match what would be found in an IPC examination.

5. Conclusion

Our study shows that tele-neurology services are feasible and highly accepted by patients in our part of the world. Whilst our findings are concordant with what has been described in other such services in resource-limited settings, we also provide unique measures of convenience in terms of time, monetary cost and travel distance saved by TNC and how that translates to reduction in healthcare-generated CO_2 emissions. Sustained delivery of TNC requires buy-in and facilitation from multiple stakeholders including healthcare workers [22]. Limitations in terms of comfort of using technology and the comparability of remote physical neurological examinations versus in-person require further work in the growing field of telemedicine.

Data analysis and management

The clinical information was compiled directly into this document without patient identifiable information and are stored on a password-protected intranet drive.

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Informed consent and patient details

Prior to the commencement of our study, we obtained approval for conducting the study from our institutional Research Ethics Committee (reference 2020/IERC-96) as well as from the National Commission of Science, Technology and Innovation (NaCoSTI). Patient identifiers were removed from the data capture form.

CRediT authorship contribution statement

Fazal Abdulaziz Yakub: Writing – original draft, Project administration, Investigation, Formal analysis, Data curation. **Jasmit Shah:** Writing – review & editing, Validation, Supervision, Methodology, Formal analysis. **Dilraj Singh Sokhi:** Writing – review & editing, Writing – original draft, Visualization, Supervision, Resources, Project administration, Methodology, Investigation, Data curation, Conceptualization.

Declaration of Competing Interest

None.

Data availability

The clinical information and imaging data used to support the findings of this study are included within the article. According to our institutional information governance regulations, the anonymised data can be requested from the corresponding author.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ensci.2023.100484.

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