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ORIGINAL ARTICLE

Green epileptology: Acceptance of telemedical follow-up under climate protection aspects

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Abstract

Objective: Expanding telemedicine services could reduce healthcare's environmental impact. This study aimed to assess the factors influencing the acceptance of telemedical follow-up in epilepsy care, with a particular focus on transportation methods, digital literacy, and environmental awareness.

Methods: The study surveyed adult patients treated at the Department of Epileptology, University Hospital Bonn, by using a 28-item questionnaire which assessed demographics, epilepsy characteristics, transportation, appointment preferences (including telemedicine), computer proficiency, online behavior, and environmental awareness.

Results: A total of 357 participants (54.6% female, 42% seizure-free, 83.8% on ASM) participated in the survey. Most (69.8%) preferred only in-person visits, 26.1% favored a hybrid model, and 4.1% preferred telemedicine exclusively. Digital literacy was high, with two-thirds reporting moderate to high proficiency in online skills, and three-quarters showed concern for environmental issues. Despite this, in-person visits remained the preferred option. Key disadvantages of telemedicine included lack of personal interaction (54.1%) and no blood tests (51.5%), whereas benefits included time savings (42.6%) and avoiding travel (52.7%). Concerns about missing in-person interaction were linked to lower telemedicine acceptance. In contrast, reduced infection risk, workplace absence, and travel avoidance, and environmental benefits were associated with a preference for a hybrid model.

Significance: Although participants expressed environmental awareness, their preference for in-person care highlights the gap between environmental attitudes and behaviors. A hybrid care model, combining telemedicine and in-person visits, appears to be the most viable solution, balancing patient needs with environmental sustainability. This study supports integrating telemedicine into routine practice as a way to reduce the carbon footprint of healthcare and enhance accessibility.

Rosa Luise Kilburg and Susanna Moskau-Hartmann shared authorship.

Plain Language Summary: This study explored whether telemedicine can reduce healthcare's environmental impact by looking at epilepsy follow-up care. A survey of 357 patients found that most preferred in-person visits (70%), while 26% favored a hybrid mix, and only 4% wanted telemedicine alone. Although digital literacy was generally high, and many cared about the environment, face-to-face care remained the preferred option. Patients valued saving travel time and avoiding infection risk with telemedicine but missed personal interaction and blood tests. The findings suggest a hybrid approach is best, offering flexibility, reducing travel emissions, and supporting sustainability while meeting patients' clinical and social needs.

KEYWORDS

climate change, digital literacy, enviromental awreness, epilepsy, telemedicine

1 | INTRODUCTION

Climate change, marked by an increase in global temperatures over the last 65 years [1], presents a substantial threat to global public health. The direct consequences, such as flooding, drought, extreme heat events, and rising sea levels, have pronounced effects on both the physical and mental health of populations [2]. A major contributor to climate change is greenhouse gas emissions, with CO_2 being the most significant contributor. The healthcare sector is responsible for about 4%–6% of global CO_2 emissions [3,4].

Telemedicine offers a promising strategy to lower healthcare-associated CO_2 emissions, with remote consultations producing only a fraction of the emissions associated with in-person visits [3,5–7]. Telemedicine has already been incorporated into the sustainability plans of the healthcare systems in the UK and several other countries [8,9]. Research indicates that telemedicine not only sustains comparable quality of care [10], but also achieves high levels of patient satisfaction [11–13].

Epilepsy, a prevalent neurological disorder, significantly impacts the quality of life [14]. In 2016, there were 45.9 million patients worldwide suffering from epilepsy, accounting for 0.56% of global disability-adjusted life years (DALY) [15]. While two-thirds of all people with epilepsy (PWE) achieve seizure control with the first two appropriately selected antiseizure medications (ASMs) [16], one-third require more complex treatment approaches that often necessitate specialized care at tertiary epilepsy centers. Climate change poses a particular risk to PWE [17] as it can exacerbate seizure precipitants, including fever, stress, sleep deprivation, vector-borne infections, and risk of sudden unexpected death in epilepsy [18]. The relationship between body temperature, heatwaves, and seizure activity remains an active area of ongoing research, underscoring the importance of understanding climate-related health impacts [19].

Key points

- 69.8% of epilepsy patients preferred in-person care despite high digital literacy and environmental concern.
- Main drawbacks of telemedicine were lack of personal contact (54.1%) and no access to tests (51.5%).
- Benefits of telemedicine included travel avoidance (52.7%) and time savings (42.6%).
- A hybrid model may best meet patient needs while supporting sustainability in healthcare.

Frequent in-person consultations impose an individual challenge, as many PWE are not fit to drive due to ongoing seizures or other handicaps and therefore rely on public transportation or travel support by others, and thereby profit from telemedical health care on an individual level. Overall, telemedical follow-up in epilepsy treatment saves time and traveled distance, showing a “feasible, sustainable, and scalable” health care approach that offers individual advantages while at the same time possibly helping to decrease CO_2 emissions and thereby supporting climate protection [20].

In response to the COVID-19 pandemic, our department had rapidly implemented a telemedicine healthcare option to ensure continuity of care for PWE while reducing potential exposure risks. Although most consultations have since returned to in-person formats, telemedicine remains available as an alternative for patient appointments. This study aims to evaluate factors influencing patient acceptance of telemedical follow-up, specifically examining transportation methods, digital engagement, online communication preferences, and environmental awareness. The primary objective is to determine whether environmental consciousness and digital literacy play a role in patients' acceptance and utilization of telemedicine services.

2 | MATERIALS AND METHODS

2.1 | Participants

Patients aged 18 or older who were counseled between January 20 and July 4, 2022, at the University Hospital Bonn, Department of Epileptology, were invited to participate in this survey. For patients with intellectual disabilities, responses were provided by an accompanying family member or caregiver. For non-native German speakers, family members or translators were asked to give answers. The ethics committee of the Medical Faculty at Rheinische Friedrich-Wilhelms University of Bonn waived the requirement for ethical approval for this study.

2.2 | Questionnaire

The questionnaire comprises 28 items, including general demographic questions (age, gender, length of time being patient at the department) and questions focusing on epilepsy itself (age at onset, current seizure frequency, use of ASM, and the total number of medications used to date). Additionally, four questions addressed transportation to our department, including the postal code of residence, mode of transport (on foot, public transport, self-driven, driven by others, or by taxi/ambulance), travel duration, and the need for overnight accommodation. Six questions addressed appointment preferences: preferred type of appointment during the COVID-19 pandemic and in general, and the desired number of telemedicine and in-person appointments if a hybrid approach is preferred. Participants favoring telemedicine were asked to specify whether they prefer phone or video consultations. Reasons against telemedicine and reasons in favor of telemedicine were also collected.

Computer affinity was self-rated on a Likert scale from 0 (no proficiency) to 6 (high proficiency). Additionally, five questions assessed online behavior, including the frequency of online purchases, types of products purchased, frequency of digital communication, daily internet use, and regularly conducted online activities in order to identify the translation of self-estimation in everyday life.

Environmental awareness was evaluated with two questions. The first assessed self-reported environmental awareness on a Likert scale from 0 (not at all aware) to 4 (highly aware). The second asked about participation in climate-conscious activities, including attending environmental demonstrations, selecting regionally sourced products, and purchasing climate-neutral goods.

Demographic data such as age at diagnosis, epilepsy syndrome, freedom of seizure (yes/no), number of ASM presently used, highest level of education, under legal care (yes/no), and time since the first visit to this epilepsy center were completed by reviewing the clinical charts. As in previous surveys, we classified seizures based on the Revised Seizure-Based Outcome Classification System (Duke), following Vickrey's criteria. This system categorizes patients into three groups: seizure-free, ≤10 seizures per year (lower seizure frequency), and >10 seizures per year (higher seizure frequency) [21]. It was used to highlight the strong correlation between seizure frequency and quality of life.

2.3 | Statistical analysis

The statistical analysis was performed using IBM SPSS Statistics (version 29). The methods used were univariate multinomial regressions and Chi^2-tests, in case of small group sizes in the target group. Due to multiple comparisons, p-values were adapted using the Bonferroni correction. p-values of <0.05 were regarded as statistically significant.

3 | RESULTS

A total of 1945 outpatients attended the clinic, of whom 357 completed the survey, resulting in a response rate of 18.48%. Demographics are shown in Table 1 and present the typical population of a tertiary university epilepsy center. Answers concerning preference about appointment type were available for 318 participants, with 222 (69.8%) preferring exclusively in-person visits, 13 (4.1%) preferring only telemedicine, and 83 (26.1%) preferring a hybrid of in-person and telemedicine appointments. A biannual appointment schedule, alternating between telemedical and in-person visits, appears to be a preferred frequency (35 participants).

The average distance from participants' homes to our department was 75 ± 64 km, with a mean travel time of

TABLE 1 Demographic.

Participants characteristics	
Female/male/diverse	195 (54.6%)/161 (45.1%9)/1 (0.3%)
Age (years, mean, SD)	42 ± 17
Age at onset of epilepsy (years, mean, SD)	25 ± 120
Duration of epilepsy (years, mean, SD)	17 ± 15
Epilepsy type	
Focal	184 (51.5%)
Generalized	52 (14.6%)
Unknown	69 (19.3%)
Non epileptic seizures (syncope/ psychogenic seizures)	17 (4.8%)
Seizure frequency	
Seizure free	150 (42%)
Lower frequency seizure	87 (24.4%)
Higher frequency seizure	119 (33.3%)
Antiseizure medication (ASM)	
On ASM	299 (83.8%)
Exposition to >2 different ASM	150 (42%)
Number of present ASM (mean, SD)	1.7 ± 1.3
History of clinic visits	
First visit at the department	122 (34.2%)
Patient at department for under 1 year	23 (6.4%)
Patient at department for 1–3 years	22 (6.2%)
Patient at department for 3–5 years	26 (7.3%)
Patient at department for over 5 years	144 (40.3%)
Educational history	
Education ≥10 years	283 (79.3%)
Education <10 years	10 (2.8%)
Special need	45 (12.6%)
No education	4 (1.1%)
No information	13 (2.7%)
Legal guardian	45 (12.6%)

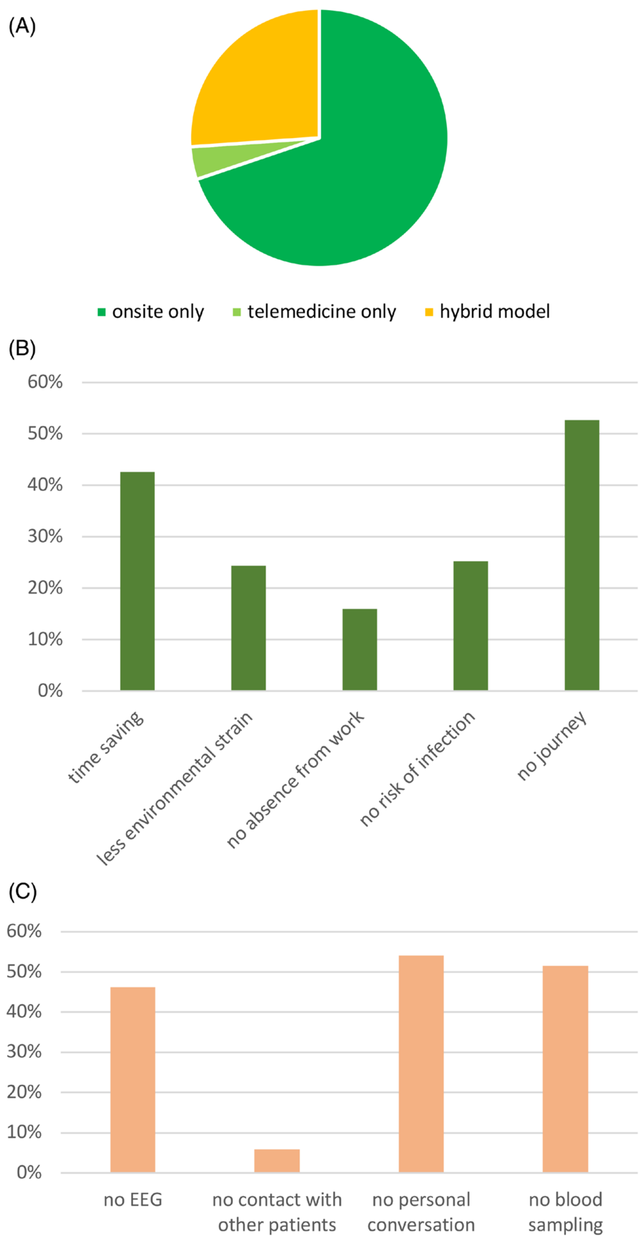

FIGURE 1 Telemedicine. (A) Preferred format of health care ($n = 318$). (B) Advantages of telemedicine. (C) Disadvantages of telemedicine.

0.8 ± 0.6 h. 62.2% of respondents were driven by others, 18.5% drove themselves, 14.9% used public transportation, 3.6% used a taxi, and 0.8% walked.

Impossibility of performing an EEG (46.2%), no contact with other patients (5.9%), no personal conversation with the physician (54.1%), and no blood test (51.5%) were considered disadvantages of telemedicine appointments. In contrast, time savings (42.6%), reduction of the environmental strain (24.4%), no journey (52.7%), not having to leave work (16%), and no risk of infection (25.2%) were considered benefits of telemedical counseling (see Figure 1).

Self-reported data on computer proficiency, online shopping habits, internet usage, and digital communication preferences are illustrated in Figure 2. These data demonstrate that at least two-thirds of the participants, both in self-perception and reported behavior, are moderately to highly digitally literate. Three-fourths of the PWE reported being moderately or very environmentally conscious, and a majority purchase climate-conscious groceries, whereas personal climate activities are rare (see Figure 3).

The statistical analysis revealed no significant associations between participants' preference for telemedicine or a hybrid model and demographic or clinical variables,

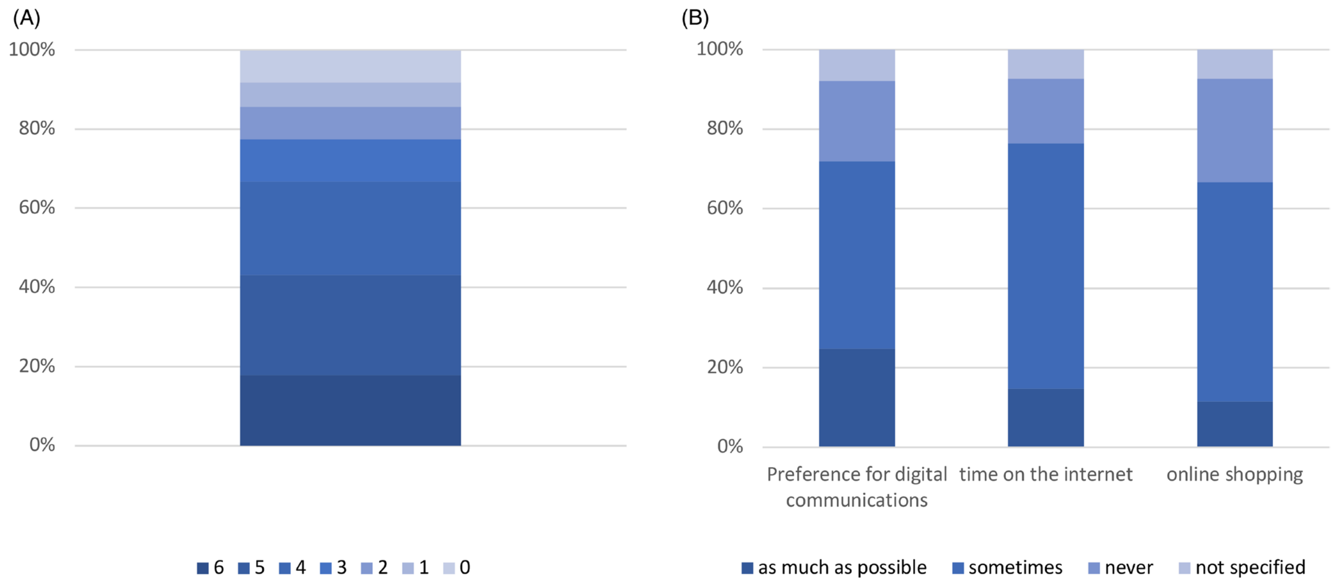

FIGURE 2 "Digitality" ($n=329$). (A) Self-rated computer affinity. (B) Digital habits.

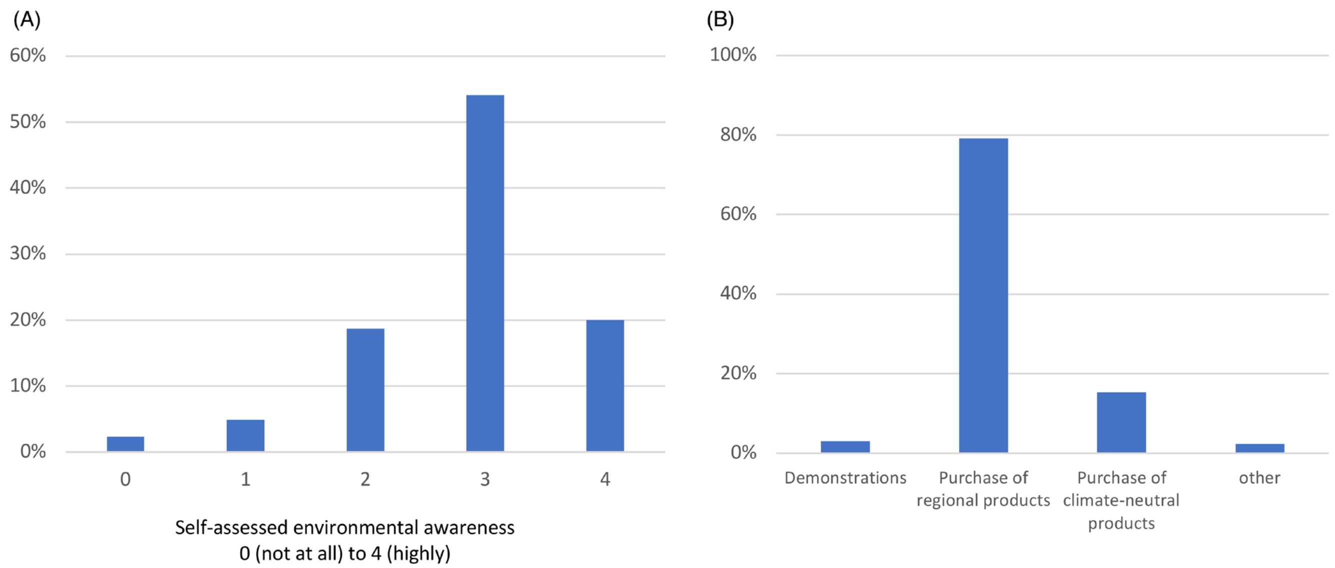

FIGURE 3 Environmental assessment. (A) Self-assessed environmental awareness ($n=305$). (B) Environmental conscious behavior ($n=130$).

such as age, gender, epilepsy type, ASM use, legal guardianship, education, length of time as a patient of this clinic, travel issues such as travel distance, travel duration, mode of transport, or self-rated computer and environmental consciousness and activities.

As expected, concerns about the lack of in-person interaction were significantly associated with a lower acceptance of telemedicine. Furthermore, reduced infection risk, avoidance of travel and workplace absence, and awareness of environmental benefits achieved by telemedicine were significantly associated with a preference for a hybrid model combining telemedicine and in-person appointments. Finally, the belief that the inability to perform EEGs was not a drawback to telemedicine was significantly associated with a preference for exclusively telemedical appointments.

4 | DISCUSSION

Climate change presents a critical global challenge that demands coordinated action across all sectors, including healthcare. The healthcare sector has a unique opportunity to contribute by expanding sustainable practices, one of which is telemedicine. Increasing the use of telemedicine can potentially reduce environmental impact by minimizing the need for in-person visits and associated travel emissions.

This study investigates whether the acceptance of telemedicine is influenced by two key factors: digital literacy and environmental awareness. Understanding these relationships may enable a more targeted and effective promotion of telemedicine as part of a broader strategy to support environmental sustainability in healthcare.

For epilepsy patients at tertiary centers, significant travel distances—and thus considerable CO_2 emissions—could be reduced by conducting at least some outpatient appointments via telemedicine by video call or telephone. Our cohort, with an average travel distance of 75 km and more than 80% traveling by car, whether by themselves or by others, represents such a group which, by switching to telemedicine, could support climate protection [9,22].

Telemedical appointments can additionally alleviate burdens on caregivers of disabled patients who may require specialized transportation (e.g., wheelchair-accessible transport), especially for those with severe physical limitations [23]. Moreover, telemedicine facilitates healthcare access for patients residing in rural or remote regions with limited local medical services. Beyond providing clinical care, it may also mitigate social and physical isolation associated with geographic disadvantage [24]. Here too, telemedicine could be advantageous, as specialists could also be reached remotely [20]. Thus, on an individual level, telemedicine appears to offer a compelling alternative for a substantial subset of patients.

However, telemedicine acceptance in our study was modest; only about one-quarter of participants expressed a preference for a hybrid model combining telemedicine and in-person visits, while the majority preferred on-site appointments only, and less than 5% preferred exclusively telemedical appointments. Prior studies have shown that satisfaction with telemedicine is generally high, with patients not perceiving telemedicine as inferior to in-person visits [25,26]. It is worth noting that all participants in this study were recruited during on-site visits, whereas our previous study recruited patients exclusively during telemedicine appointments, which were mandated during the pandemic. Thus, the two groups may not be directly comparable [25].

Patients citing the lack of in-person interaction as reasons against telemedicine were more likely to prefer in-person appointments. An approach to enhance telemedicine quality and patient satisfaction could involve arranging nearby facilities for essential laboratory tests, with results forwarded to treating physicians, or remote neuropsychological testing [27].

Two thirds of the participants indicated a high level of self-rated computer literacy, suggesting that technical proficiency is unlikely to be a barrier to telemedicine acceptance. Most participants reported at least a moderate comfort level with online communication and internet use, suggesting that technical difficulties are not a primary concern. High and higher digital literacy in both self-perception and reported behavior is consistent with our cohort of predominantly digital natives (mean age 42).

The surprisingly high portion of patients who prefer face-to-face appointments might not only be due to the lack of opportunity for EEG and laboratory checks, and face-to-face conversations were named as main disadvantages; it may also be driven by the familiarity and routine of on-site care, particularly since 40.3% of the participants have been visiting our epilepsy center for more than 5 years. Additionally, high satisfaction with on-site appointments likely contributes to their reluctance to transition to telemedicine. Germany's healthcare sector lags in digitalization compared to other EU countries [28,29], which may influence patient unfamiliarity with digital medicine and eHealth services, possibly contributing to a preference for in-person visits.

Regarding environmental awareness, at least two-thirds of participants rated themselves as environmentally conscious, indicating that environmental considerations may factor into everyday decisions. Nevertheless, in-person appointment preferences appear to be more important, underlining the attitude–behavior gap, that is, that a high level of environmental awareness does not necessarily mean a change in behavior [29]. Still, many patients may not fully recognize the environmental impact of the healthcare sector [30] and the potential of telemedicine to reduce CO_2 emissions. Although many people are environmentally aware and support climate protection, they are often unwilling to bear higher costs or personal inconvenience [31]. With this, as telemedicine is associated not only with lower costs, that is, expenses for traveling, and higher convenience, it might thereby circumnavigate these obstacles. Considering the previously proposed low-cost hypothesis of environmental behavior, which states that concerned individuals take low-cost actions to reduce the cognitive dissonance between their environmental attitudes and the effects of their behavior, but avoid more costly actions despite their greater potential for environmental protection, highlights the underutilized potential of telemedicine [32]. Therefore, linking telemedicine with environmental considerations can motivate PWE to use the benefits of telemedicine for individuals as well as the environment. In our analysis, most variables did not significantly correlate with a preference for telemedicine. However, environmental impact reduction, reduced work absence, and lower infection risk were associated with a preference for hybrid telehealth and in-person visits. This underscores the ongoing importance of in-person care, suggesting a hybrid model may be the optimal approach for integrating telehealth into epilepsy care. Other studies have identified various barriers and facilitators to telemedicine acceptance, with prominent barriers including resistance to change, negative perceptions of telemedicine, slow internet speeds, and poor network connectivity. Key facilitators include high-speed internet, training for patients and healthcare providers, user-friendly telemedicine platforms, time savings, and convenience [26]. Considering these factors will be crucial in developing satisfactory telemedicine options that are responsive to patients' needs. Increasing patients' satisfaction will be a vital driver in promoting telemedicine adoption.

This study has several limitations. As the survey was done onsite, individuals who were using telemedicine at the enrolment phase might be underrepresented. Additionally, our department is a highly specialized clinic with a higher-than-average number of complex cases. Since participation was voluntary, there is a potential for selection bias, with environmentally conscious individuals possibly being overrepresented. Moreover, the self-assessment nature of the survey could introduce bias due to social desirability, potentially leading to an overestimation of environmental awareness and technology skills, while actual internet usage and time spent online may be underestimated.

5 | CONCLUSION

In conclusion, there are numerous reasons to implement telemedicine in routine clinical practice, not the least of which is the urgent need to reduce healthcare's environmental impact in the face of climate change. As healthcare providers, we have an ethical responsibility to minimize the sector's environmental impact to support sustainable health and well-being for current and future generations. While skepticism about telemedicine remains among patients, epilepsy patients in particular stand to benefit significantly from its implementation. As with any shift in healthcare practices, adapting values and priorities is essential to balance patient care with broader societal benefits.

AUTHOR CONTRIBUTIONS

Rosa Luise Kilburg: data curation, investigation, validation, formal analysis, writing—original draft, visualization. **Susanna Moskau-Hartmann:** data curation, investigation, validation, formal analysis, writing—original draft, visualization. **Christoph Helmstaedter:** methodology, software, validation, formal analysis, writing—review. **Rainer Surges:** formal analysis, validation, writing—review. **Randi von Wrede:** conceptualization, methodology, software, investigation, validation, formal analysis, writing—review and editing, supervision.

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CONFLICT OF INTEREST STATEMENT

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

ETHICS STATEMENT

We confirm that we have read the Journal's position on issues involved in ethical publication and affirm that this report is consistent with those guidelines.

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During the preparation of this work, the authors used ChatGPT by OpenAI in order to improve readability. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the published article.

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