Asynchronous Distance Learning Performance and Knowledge Retention of the NIH Stroke Scale among Health Care Professionals using Video or E-learning: A Web-based Randomized Controlled Trial

Avinash Koka, Loric Stuby, Emmanuel Carrera, Ahmed Gabr, Margaret O'Connor, Nathalie Missilier Peruzzo, Olivier Waeterloot, Friedrich Medlin, Fabien Rigolet, Thomas Schmutz, Patrik Michel, Thibaut Desmettre, Mélanie Suppan, Laurent Suppan

Submitted to: Journal of Medical Internet Research
on: June 11, 2024

Table of Contents

Asynchronous Distance Learning Performance and Knowledge Retention of the NIH Stroke Scale among Health Care Professionals using Video or E-learning: A Web-based Randomized Controlled Trial

Avinash Koka[1] MD; Loric Stuby[2]; Emmanuel Carrera[3] MD; Ahmed Gabr[4] MD; Margaret O'Connor[4] MD; Nathalie Missilier Peruzzo[3] RN; Olivier Waeterloot[3] RN; Friedrich Medlin[5] MD; Fabien Rigolet[5]; Thomas Schmutz[6] MD; Patrik Michel[7] MD; Thibaut Desmettre[8] MD; Mélanie Suppan[9] MD; Laurent Suppan[8] MD

[1]Genève TEAM Ambulances Emergency Medical Services Geneva CH
[2]Stroke Centre Department of Neurology Geneva University Hospitals and Faculty of Medicine, University of Geneva Geneva CH
[3]Department of Ageing and Therapeutics University of Limerick Hospital Group University Hospital Limerick Limerick IE
[4]Stroke Unit Division of Neurology Fribourg Cantonal Hospital Fribourg CH
[5]Department of Emergency Medicine Fribourg Cantonal Hospital Fribourg CH
[6]Stroke Centre Division of Neurology, Department of Clinical Neurosciences Lausanne University Hospital Lausanne CH
[7]Division of Emergency Medicine Department of Anaesthesiology, Clinical Pharmacology, Intensive Care and Emergency Medicine Geneva University Hospitals and Faculty of Medicine, University of Geneva Geneva CH
[8]Division of Anesthesiology Department of Anaesthesiology, Clinical Pharmacology, Intensive Care and Emergency Medicine Geneva University Hospitals and Faculty of Medicine, University of Geneva Geneva CH

Corresponding Author:
Avinash Koka MD

Abstract

Background: Stroke treatment has significantly improved over the last decades, but the complexity of stroke cases requires specialized care especially in the first days after onset. To reliably assess neurological deficits, health care professionals (HCPs) must be highly trained, particularly in the usage of the widely used National Institutes of Health Stroke Scale (NIHSS). Traditional didactic methods may not adequately address certain intricacies of NIHSS nor engage HCPs in continuous learning, leading to suboptimal proficiency. In the context of time-constrained clinical settings, e-learning could be a promising alternative for knowledge dissemination and skill acquisition.

Objective: This study aimed to assess the efficacy of a highly interactive e-learning module compared to a traditional didactic video in improving NIHSS knowledge among previously trained HCPs.

Methods: A prospective, multi-centric, triple-blind, web-based randomized controlled trial was conducted involving previously trained HCPs working in three Swiss hospitals. Invitation to participate was sent via email, and participants were randomized to either the e-learning or traditional didactic video group through a fully automated process upon self-registration. Pre- and post-training quizzes were administered to assess knowledge acquisition, with a follow-up quiz after one month to evaluate retention. Subjective assessments of learning methods were also collected.

Results: Of 174 enrolled participants, 97 completed the study course. Both learning methods significantly improved NIHSS knowledge, with the e-learning group demonstrating higher scores in knowledge acquisition (median score: 39 vs 37, P=.031) and retention (mean score: 38.2 vs. 35.8). Participants in the e-learning group were significantly more likely to recommend the learning method (P=.024).

Conclusions: A highly interactive e-learning module was found to be an effective asynchronous method for NIHSS knowledge acquisition and retention, in previously NIHSS-trained HCPs, and should therefore be integrated into NIHSS training programs.

(JMIR Preprints 11/06/2024:63136)
DOI: https://doi.org/10.2196/preprints.63136

Preprint Settings

1) Would you like to publish your submitted manuscript as preprint?

✓ **Please make my preprint PDF available to anyone at any time (recommended).**
Please make my preprint PDF available only to logged-in users; I understand that my title and abstract will remain visible to all users.
Only make the preprint title and abstract visible.
No, I do not wish to publish my submitted manuscript as a preprint.

2) If accepted for publication in a JMIR journal, would you like the PDF to be visible to the public?

✓ **Yes, please make my accepted manuscript PDF available to anyone at any time (Recommended).**
Yes, but please make my accepted manuscript PDF available only to logged-in users; I understand that the title and abstract will remain v
Yes, but only make the title and abstract visible (see Important note, above). I understand that if I later pay to participate in <a href="http

Original Manuscript

Asynchronous Distance Learning Performance and Knowledge Retention of the NIH Stroke Scale among Health Care Professionals using Video or E-learning: A Web-based Randomized Controlled Trial

Authors
Avinash KOKA[1], MD, avinash.koka@hug.ch ORCID: 0000-0002-3911-0528
Loric STUBY[2], l.stuby@gt-ambulances.ch ORCID: 0000-0003-1663-5249
Emmanuel CARRERA[3], MD, emmanuel.carrera@hug.ch ORCID: 0000-0003-0045-5382
Ahmed GABR[4], MD, ahmed.gabr@hse.ie ORCID: 0000-0002-8577-3541
Margaret O'CONNOR[4], MD, margaret.oconnor9@hse.ie ORCID: 0000-0001-9984-9204
Nathalie MISSILIER PERUZZO[3], RN, nathalie.peruzzo-missillier@hug.ch ORCID: 0009-0005-6789-9473
Olivier WAETERLOOT[3], RN, olivier.waeterloot@hug.ch ORCID: 0009-0000-1684-3000
Friedrich MEDLIN[5], MD, friedrich.medlin@h-fr.ch ORCID: 0000-0002-8477-899X
Fabien RIGOLET[5], RN, fabien.rigolet@h-fr.ch ORCID: 0009-0004-1445-5070
Thomas SCHMUTZ[6], MD, thomas.schmutz@h-fr.ch ORCID: 0000-0003-2484-3531
Patrik MICHEL[7], MD, patrik.michel@chuv.ch ORCID: 0000-0003-4954-7579
Thibaut DESMETTRE[1], MD, thibaut.desmettre@hug.ch ORCID: 0000-0003-4585-5494
Mélanie SUPPAN[8], MD, melanie.bochet@hug.ch ORCID: 0000-0002-8807-9619
Laurent SUPPAN[1], MD, laurent.suppan@hug.ch ORCID: 0000-0001-6989-6421

[1]Division of Emergency Medicine, Department of Anaesthesiology, Clinical Pharmacology, Intensive Care and Emergency Medicine, Geneva University Hospitals and Faculty of Medicine, University of Geneva, Switzerland
[2]Genève TEAM Ambulances, Emergency Medical Services, Geneva, Switzerland
[3]Stroke Centre, Department of Neurology, Geneva University Hospitals and Faculty of Medicine, University of Geneva, Switzerland
[4]Department of Ageing and Therapeutics, University of Limerick Hospital Group University Hospital Limerick, Limerick, Ireland
[5]Stroke Unit, Division of Neurology, Fribourg Cantonal Hospital, Fribourg, Switzerland
[6]Department of Emergency Medicine, Fribourg Cantonal Hospital, Fribourg, Switzerland.
[7]Stroke Centre, Division of Neurology, Department of Clinical Neurosciences, Lausanne University Hospital, Switzerland
[8]Division of Anaesthesiology, Department of Anaesthesiology, Clinical Pharmacology, Intensive Care and Emergency Medicine, Geneva University Hospitals and Faculty of Medicine, University of Geneva, Switzerland

Abstract word count: 285
Main text word count: 3923
Total word count: 7016
Tables: 2
Figures: 5
References: 35
Multimedia Appendix: 7

Funding: None

Corresponding author:
Dr Laurent SUPPAN
laurent.suppan@hug.ch
Division of Emergency Medicine
Department of Anaesthesiology, Clinical Pharmacology, Intensive Care and Emergency Medicine, Geneva University Hospitals
Rue Gabrielle-Perret-Gentil 4, CH-1211 Geneva 14, Switzerland
+41223723311

ABSTRACT

Background: Stroke treatment has significantly improved over the last decades, but the complexity of stroke cases requires specialized care especially in the first days after onset. To reliably assess neurological deficits, health care professionals (HCPs) must be highly trained, particularly in the usage of the widely used National Institutes of Health Stroke Scale (NIHSS). Traditional didactic methods may not adequately address certain intricacies of NIHSS nor engage HCPs in continuous learning, leading to suboptimal proficiency. In the context of time-constrained clinical settings, e-learning could be a promising alternative for knowledge dissemination and skill acquisition.
Objective: This study aimed to assess the efficacy of a highly interactive e-learning module compared to a traditional didactic video in improving NIHSS knowledge among previously trained HCPs.
Methods: A prospective, multi-centric, triple-blind, web-based randomized controlled trial was conducted involving previously trained HCPs working in three Swiss hospitals. Invitation to participate was sent via email, and participants were randomized to either the e-learning or traditional didactic video group through a fully automated process upon self-registration. Pre- and post-training quizzes were administered to assess knowledge acquisition, with a follow-up quiz after one month to evaluate retention. Subjective assessments of learning methods were also collected.
Results: Of 174 enrolled participants, 97 completed the study course. Both learning methods significantly improved NIHSS knowledge, with the e-learning group demonstrating higher scores in knowledge acquisition (median score: 39 vs 37, P=.031) and retention (mean score: 38.2 vs. 35.8). Participants in the e-learning group were significantly more likely to recommend the learning method (P=.024).
Conclusion: A highly interactive e-learning module was found to be an effective asynchronous method for NIHSS knowledge acquisition and retention, in previously NIHSS-trained HCPs, and should therefore be integrated into NIHSS training programs.

Keywords: stroke, e-learning, video, medical education, online learning, randomized controlled trial, knowledge retention, knowledge acquisition, NIHSS, learner satisfaction

INTRODUCTION

Background

Despite the decline in stroke incidence and mortality since 1990, the absolute number of stroke cases are increasing as a result of the steep growth in the global population, along with an ageing demographic and greater burden of risk factors across many parts of the world [1]. Hence, stroke remains a major public health issue due to its high morbidity rates [2]. Acute reperfusion therapies, such as intravenous thrombolysis and thrombectomy, improve functional and survival prognosis after stroke [3,4]. However, patients must be carefully screened and selected, and these procedures must

be performed within a limited timeframe, due to risks and complications associated with the treatment [3].

The National Institutes of Health Stroke Scale (NIHSS) is widely used around the world to triage, select treatment strategies, monitor and follow-up stroke patients [3,5]. First described in the late 80s, it gained popularity after the publication of the first successful acute stroke treatment study [5,6]. The reliability of the NIHSS has been demonstrated across diverse populations of health care professionals (HCPs) [7,8]. However, prior training and certification is required [9–14] as it is a complex scale with numerous subtleties. In the French-speaking part of Switzerland, all HCPs working in stroke units should be familiar with NIHSS, although training is non-standardized and centre-specific [15–17].

Constraints of working in these 24-hour acute care units, such as unexpected inflow of patients, weekend, and night shift patterns, can limit HCPs exposure to regular clinical training sessions. The absence of time constraints and the self-paced nature of asynchronous digital learning methods such as electronic learning (e-learning) modules have contributed to their popularity in medical education [18], and have been extensively used during the coronavirus pandemic [19,20]. Hence, a highly interactive e-learning module was created to teach the NIHSS [21]. Its use has been shown to improve user satisfaction, knowledge acquisition as well as dissemination in NIHSS-naive populations, when compared to the traditional didactic video alone [22,23].

Despite widespread usage of the NIHSS, little literature exists on the actual performance of HCPs using it on a regular basis. Over time, with routine practice and bedside training, some key aspects of NIHSS scoring may be overlooked, improperly practiced, or forgotten. Therefore, we hypothesized that even previously trained HCPs may have suboptimal NIHSS knowledge, and that a refresher course using an e-learning module could be more effective than the traditional didactic video at improving their NIHSS proficiency. Further, we also hypothesized that knowledge retention at one month would be higher after following this interactive module than after reviewing the standard didactic video.

Objectives

Our primary objective was to assess whether NIHSS-trained HCPs would significantly improve their NIHSS knowledge after completing a highly interactive e-learning module than after following the traditional didactic video. The secondary objective was to determine whether following either training material allowed better retention of knowledge at one month.

METHODS

Study Design and Setting

This was a prospective, multi-centric, web-based, triple-blind (participants, investigators, data analyst) randomized controlled trial that was carried out following the CONSORT-eHealth guidelines [24] and integrating relevant elements from the Checklist for Reporting Results of Internet E-Survey (CHERRIES) (Figure 1) [25]. The study protocol has been previously published [26].

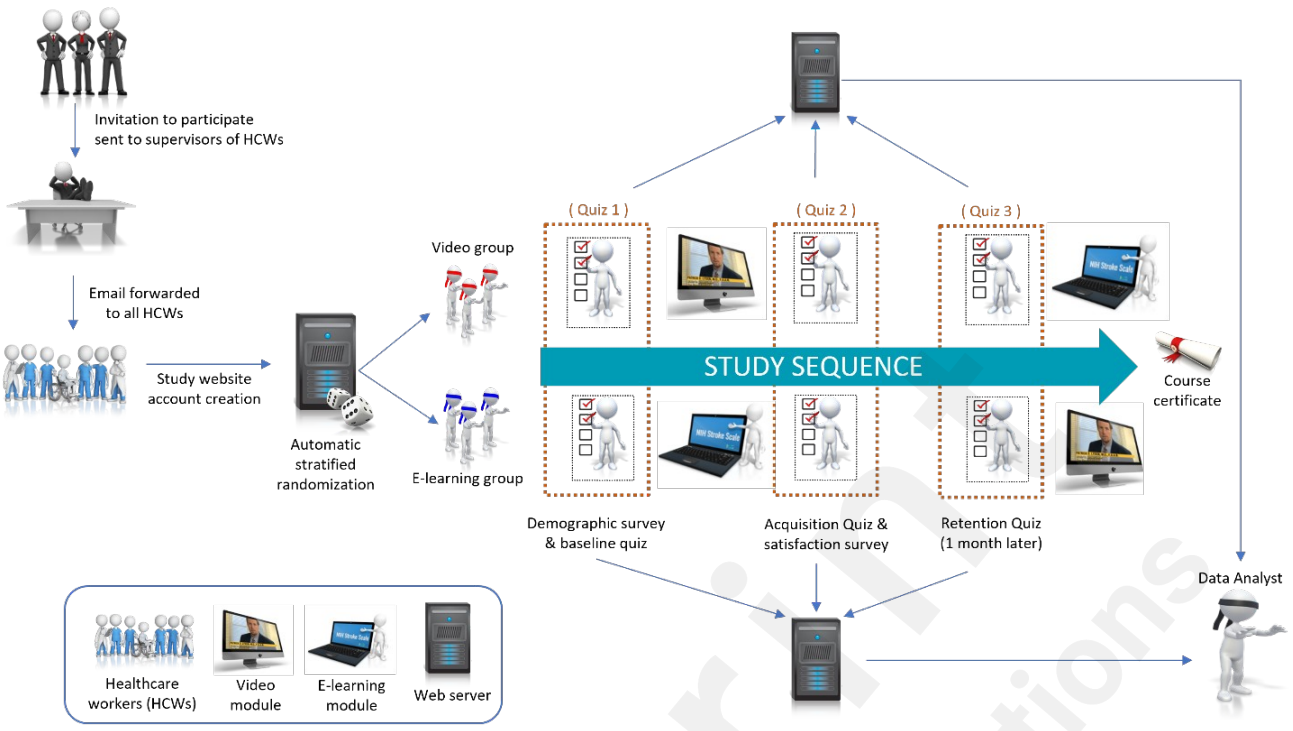


Figure 1. Study design.

This study was initially designed to include HCPs from the stroke units and neurology wards of two university hospitals in the French-speaking part of Switzerland, namely the Geneva University Hospitals (HUG) and the University Hospital of Lausanne (CHUV). A third centre, the Cantonal Hospital of Fribourg (HFR), joined the study a few weeks before its launch. HFR supervisors also extended the study invitation to all their personnel who potentially used the NIHSS on a regular basis, which included intensive care unit HCPs and emergency ward nurses.

The medical and nursing supervisors of all three centres forwarded an invitation email to their teams, containing a summary of the main points of the study and a link to the online platform. One author (LSu, Laurent Suppan) sent weekly email updates to the supervisors of each centre summarizing the number of participants in each hospital, stratified by profession. This email also detailed the number of participants at each stage of the study, thus enabling supervisors to monitor participation. Reminder emails regarding enrolment were left to the discretion of the supervisors. Automatic reminders were sent to participants who had registered on the platform but had not completed the required and appropriate study steps.

The initial invitation email was sent in July 2022. Enrolment and registration of new participants was disabled on March 31, 2023, and ongoing participants were invited to complete all steps by May 31, 2023. While the study platform remained accessible for scientific purposes such as further data extraction, users were no longer able to log in.

Online platform

The internet-based online study platform, compliant with GDPR (General Data Protection Regulation), was created using the Joomla 3.10 content management system (Open Source Matters). Participants were assigned to specific user groups according to their progression using Joomla's Access Control List. Custom PHP code was embedded using Sourcerer 9 (Regular Labs) to manage user group assignment.

The self-enrolment process was entirely automated. The first page of the website contained all necessary information regarding the study, and the consent information form was downloadable.

Participants were explicitly informed that completing the registration process implied consent to participate in the study. Those who wished to enrol had to click on the logo of their hospital before acknowledging their profession (doctor or nurse) by clicking on a captioned image. This procedure invisibly randomized them either to the video or to the e-learning group using Gegabyte's Random Article module 2.3. Since the number of potential participants could not be predicted, there was no way to ensure a 1:1 allocation. Participants were then asked to self-evaluate their current NIHSS knowledge (limited, moderate, or extended). The Membership Pro 3 component (Joomdonation) was then used to show a simple registration form which only asked for an email address and a secure password.

First Questionnaire

After completing the registration process, participants were asked to fill in a first questionnaire (Multimedia Appendix 1) designed to collect demographic data, administered using the Community Surveys 5.6 component (Shondalai) [27]. A detailed description of the first questionnaire can be found in the study protocol [26].
Participants then completed a 50-question quiz designed to assess their baseline knowledge (quiz 1). Completion of this first quiz granted access to the allocated learning material as per randomization.

Learning Material and Second Questionnaire

The video group was given access to the original, subtitled video created by Professor Lyden, which is freely available online under a Creative Commons licence [28].
The e-learning group was given access to version 21c of the interactive e-learning module created under Storyline 3 (Articulate Global) [21]. This module, which contains 184 interactive slides, is divided into chapters following the NIHSS structure. Subtitled excerpts of Professor Lyden's original video are embedded into the different chapters to illustrate clinical testing. This e-learning module has been extensively described in previous publications as well as in the protocol of this study [22,23,26].
Participants had full control of the allocated learning material, could go back and forth as often as needed, pause, resume, restart and review chapters, all without constraints or time limitation. Upon completion of the learning material, participants were then taken through the same 50-question quiz to assess knowledge acquisition (quiz 2).
This quiz was followed by a short satisfaction survey collecting subjective outcomes (i.e., satisfaction, difficulty, duration, and likelihood of recommendation) using a 5-point Likert scale (Multimedia Appendix 2).

Knowledge retention

Four weeks after completion of the satisfaction survey, participants were invited via email to complete the final quiz. They were asked to answer the 50-question quiz a third time to assess knowledge retention (quiz 3). At the end of this quiz, a certificate of participation was automatically generated that could be downloaded and printed. Only the email ID used for registration appeared automatically on the certificate, and participants were asked to write their names down after printing it. Each certificate was embedded with a unique barcode that could be scanned for verification of authenticity.

Outcomes

The primary outcome was knowledge acquisition, assessed by the score on the second quiz, taken after completing the learning material.
Secondary outcomes were:
- knowledge retention, assessed by the score on the third quiz undertaken at least one month after

completion of the learning material.
- subjective assessment of followed learning method, i.e., user satisfaction, user perception of the duration, perceived difficulty, and likelihood of recommending the learning material to a colleague.

Participants and Sample size

Seventy-two participants were required to have 80% chance of detecting a difference of 2 points in the post-course 50-question quiz between groups at the 5% significance level. Considering a 40% attrition rate, we aimed to recruit 120 participants. A higher number of participants were accepted as participation did not entail any risk.

Data Curation and Statistical Analysis

Data curation and statistical analysis were carried out using Stata 15.1 (StataCorp LLC, College Station, TX, USA). Data curation was done by one author LSu (Laurent Suppan), who assigned neutral names to the e-learning group and the video group. Another author, LSt (Loric Stuby), was then given this curated and blinded DTA file for data analysis. Continuous variables were first graphically described to look for the shape of the distribution. In case of doubtful normality, the Shapiro-Wilk test was applied. Then, depending on the variable's distribution, either Student's t-test or the Mann-Whitney U test were used. Results are reported either using mean (95%CI) or median [quartiles].
A sensitivity analysis was performed by excluding those who had previously followed either the e-learning module or the original video from Patrick Lyden [20]. Categorical variables (e.g., Likert scales) were first analysed graphically, then using the Fisher's exact test.
The time interval between the end of quiz 2 and start of quiz 3 was also analysed to ensure that the time elapsed before assessing retention was not lower than required as per the original protocol.
The data file has been uploaded to the Mendeley Data repository.

Protocol deviations

Several protocol deviations must be mentioned:
- Clarification of the primary outcome: reviewing the published protocol before data analysis pointed out an inconsistency in defining the primary outcome. In the outcomes' section, we stated the primary outcome as the difference between the score on the 50-question quiz answered before and after following the allocated material. However, in the objectives, we stated that the primary objective was to determine if NIHSS knowledge improved more significantly in the e-learning group compared to the video; further, in the sample size calculation, we sought to look for a difference of 2 points in the post-course questionnaire. Prior to performing the statistical analysis, we clarified our primary outcome: as we did not expect to find a difference in baseline knowledge between both groups due to the randomized design of the study, and given that the main goal of this study was to evaluate the impact of the learning method on knowledge acquisition, the primary outcome was defined as knowledge acquisition, assessed by the score difference on the post-training quiz (quiz 2) between groups.
- Reporting of baseline knowledge: the initial protocol planned to provide a cross-sectional description of the baseline performance in addition to the current results. However, as a sizeable proportion of participants did not complete the study pathway but have answered the baseline quiz, the cross-sectional description will be reported in a separate paper, which will enable analysis of the complete dataset and enable more in-depth analysis (profession, self-assessed prior NIHSS experience, centre, self-assessed comfort with use, exposition to the scale, and gender). Baseline performance of those having completed the study pathway are mentioned in table 1.
- Statistical analysis: in the protocol, we had planned to analyse the data using linear regression models. However, considering that the randomized design of the study would also randomize any

confounding variables, we decided to simplify the statistical analysis before the end of data collection, as described in the “Data Curation and Statistical Analysis” section above.
- Time interval between assessment of knowledge acquisition and retention: The online platform was developed based on the assumption that participants would progress through all the components of each group, as detailed above, in a single session. Thus, the automatic email inviting participants to proceed to the third quiz was configured to be sent one month after activation of step 2, not after its completion. The authors quickly noticed that participants often paused their progression and resumed a few days or even weeks later. To manage this unforeseen issue, individual progression was reviewed on a weekly basis and the dispatch of the email inviting participants to access the retention questionnaire was adapted accordingly.
- Specific time interval outcomes: the voluntary pauses in progression described above make time interval comparison between groups uninterpretable. It was thus decided to remove these outcomes from data analysis.
- Correction of affiliations: all centres provided continuing education credit (5 hours) for participation in the study. In this process, one staff supervisor noticed that the participation numbers provided by the authors did not tally with his list of participants. Data verification identified that some participants had clicked on the wrong hospital affiliation during the registration process. All email IDs were therefore screened and affiliations corrected whenever relevant. While this was straightforward when participants had used their professional email IDs, centre coordinators were asked to manually review specific addresses in case of doubt.

Ethics

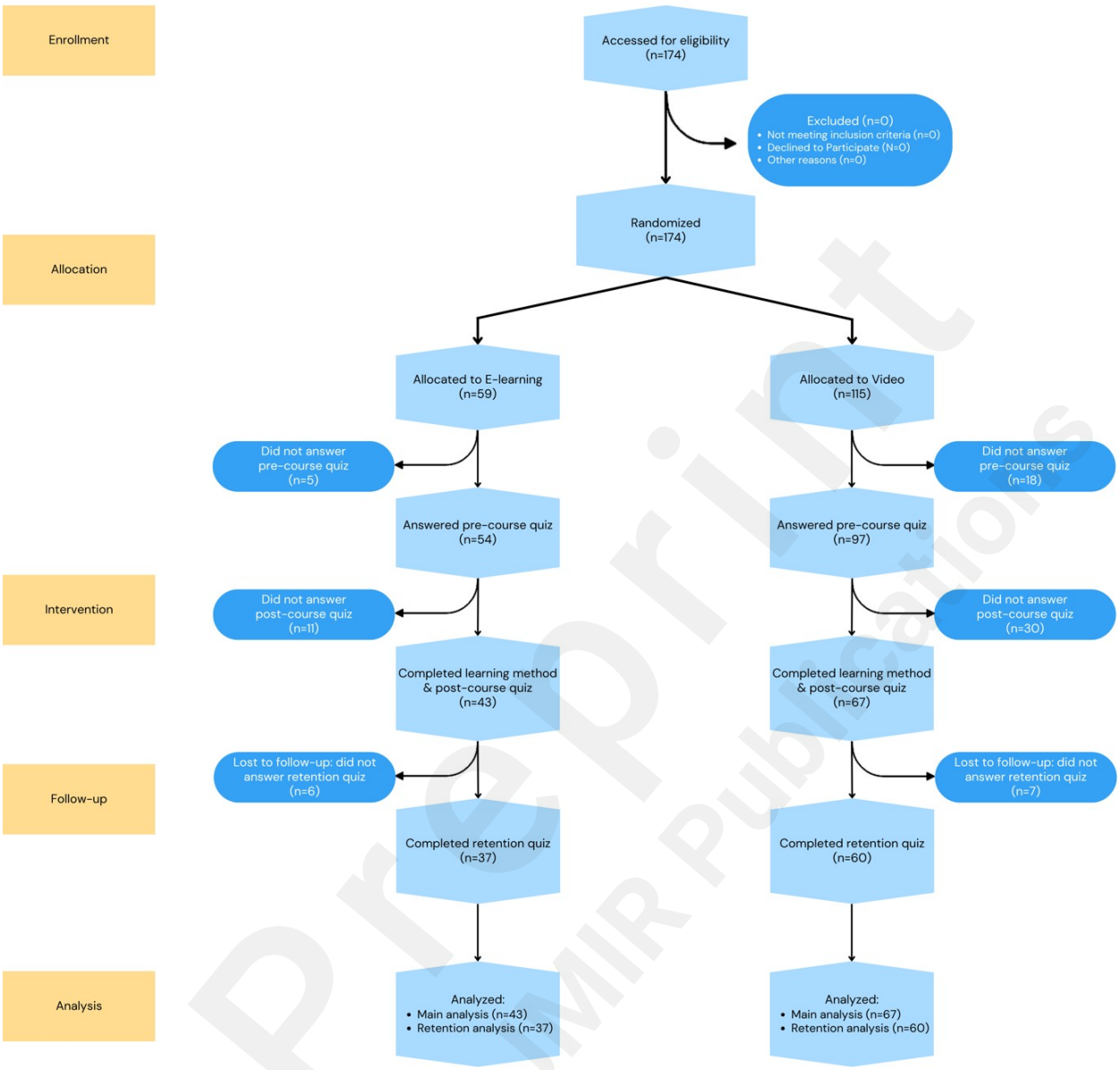
The regional ethics committee issued a “Declaration of no objection” in response to a jurisdictional query that we submitted (Req-2021-00543), as this study does not involve patients and falls outside the scope of the Swiss legislation regulating research on human subjects.

RESULTS

Participants Characteristics

A total of 174 participants enrolled in the study. The fully automated randomization process attributed 59 participants to the e-learning group, and 115 participants to the video group (Figure 2). Characteristics of participants having completed the study path are described in Table 1. Given the high attrition rates, the characteristics of the participants who dropped out were also extracted and are displayed in Multimedia Appendix 3.

Figure 2. Study flowchart



Participation according to group allocation

A difference of 10.5% in the participation rate was found, with 37/59 (62.7%) participants completing the study course in the e-learning group versus 60/115 (52.2%) in the video group.

Knowledge acquisition

Both learning methods had a positive impact on knowledge acquisition as both groups improved their scores. The improvement in the e-learning group was of 3.14 points (2.03-4.34), and of 2.12 points (1.16-3.08) in the video group.
Participants who followed the e-learning method performed better in the acquisition quiz than the participants in the video group (score of 39 [36,41] versus 37 [34,39], P=.031) (Figure 3).

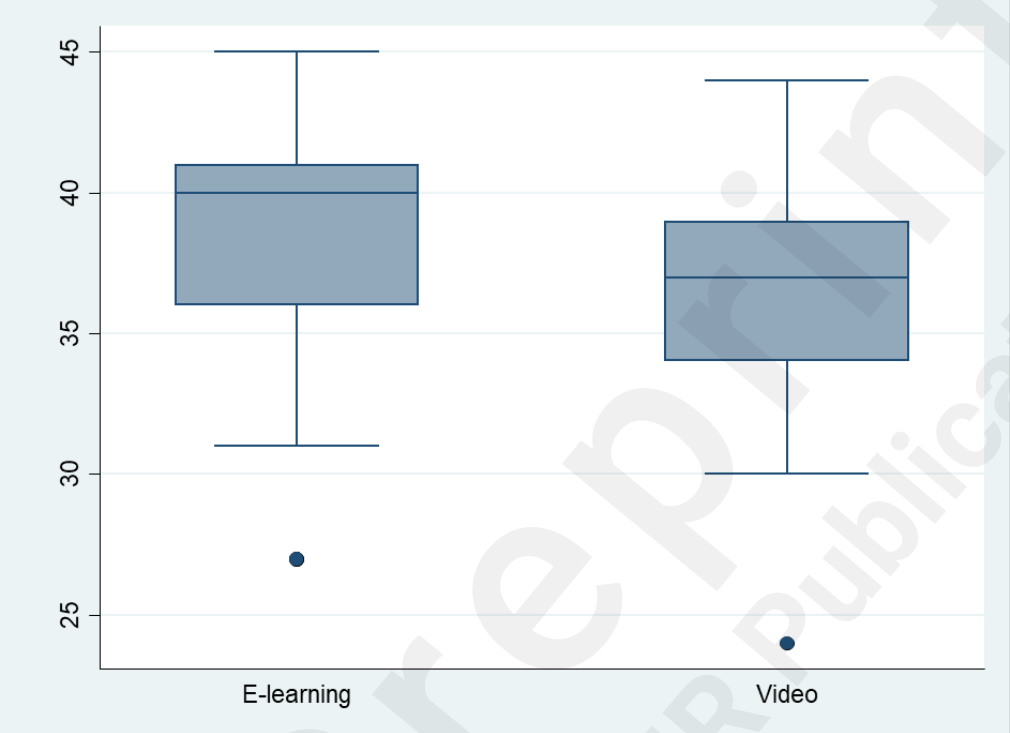


Figure 3. NIHSS knowledge acquisition quiz (quiz 2) among groups.

Knowledge retention

The participants who followed the e-learning module had significantly higher scores at the retention quiz (38.2 [CI95% 36.7 to 39.7] vs 35.8 [34.8 to 36.8]) (Figure 4).

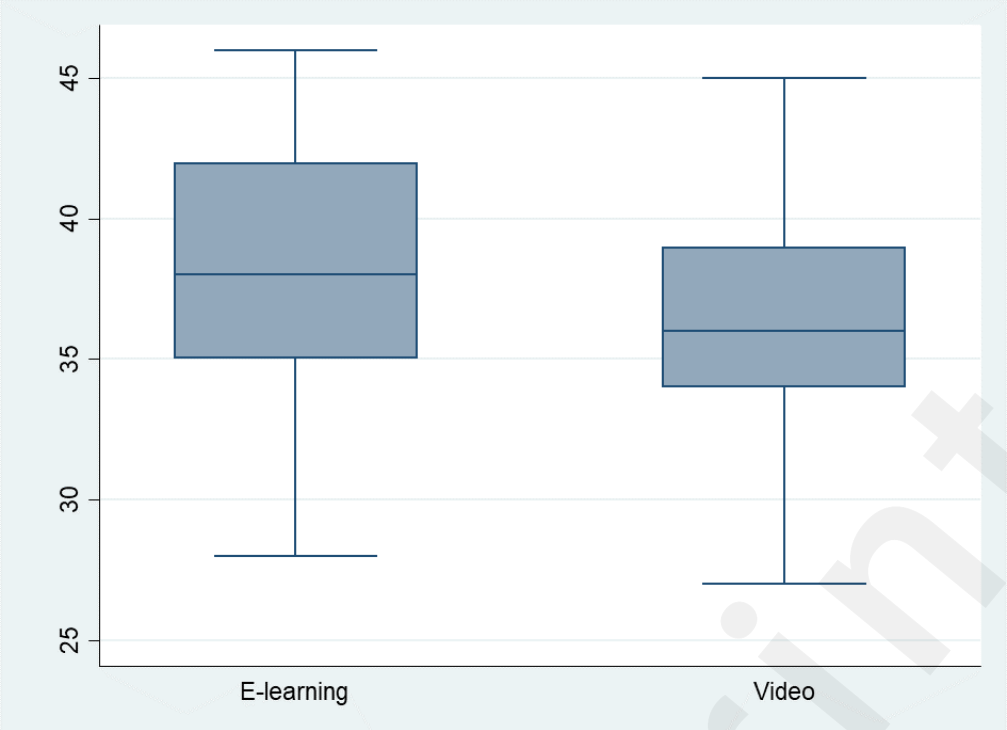


Figure 4. NIHSS knowledge retention quiz (quiz 3) among groups.

Subjective assessments

The likelihood of recommending the learning method was statistically higher in the e-learning group (P =.024) (Figure 5). There was no significant difference regarding satisfaction (P =.171), perceived duration (P =.169) and difficulty (P =.318) (Multimedia Appendix 4-6).

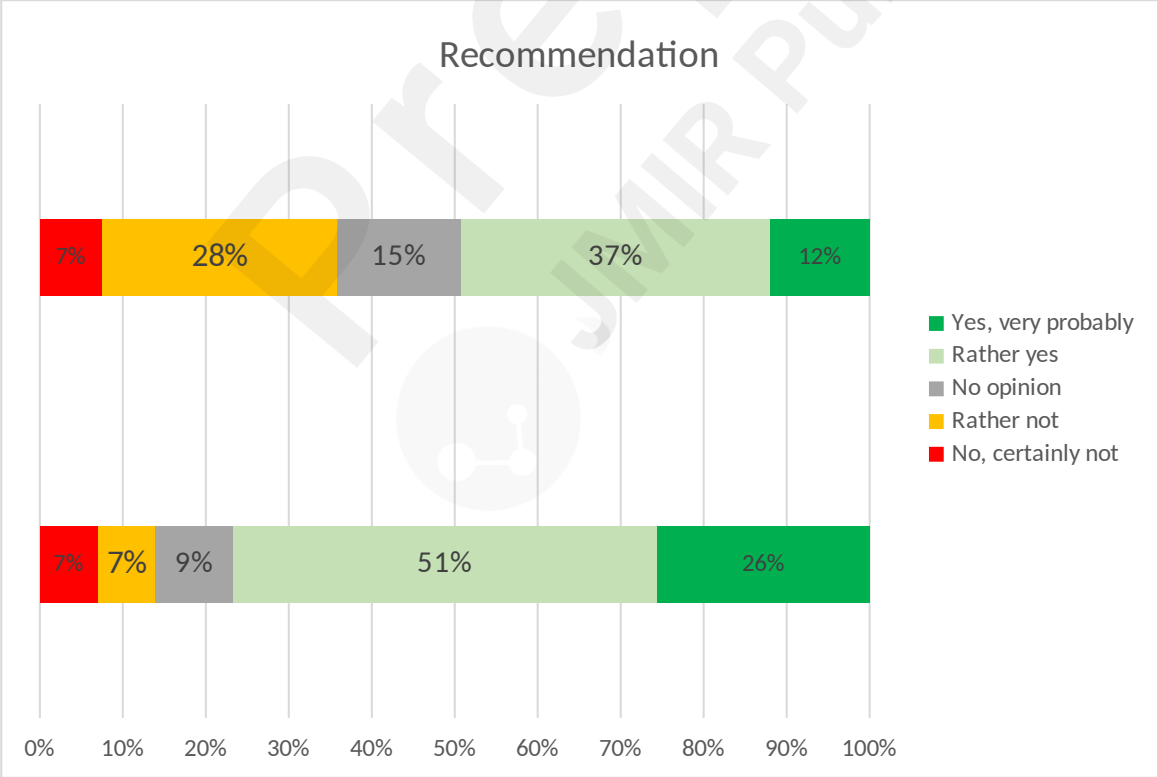


Figure 5. Likelihood of recommending the learning method to a colleague

Sensitivity analysis

The prespecified sensitivity analysis (i.e., excluding those who had previously followed either learning method) did not change the results (Table 2).

Table 2. Characteristics of participants having completed the study path.

	E-learning	Video	*P* value
Sensitivity analysis of primary outcome (knowledge acquisition), median [quartiles]	39 [37;41]	36 [34;39]	.014
Sensitivity analysis of knowledge retention, mean (95%CI)	38.3 (36.7 to 39.9)	35.5 (34.5 to 36.5)	.003

DISCUSSION

Main considerations

The higher scores obtained after following the e-learning module compared to the video demonstrates that a highly interactive e-learning module is more efficient in improving NIHSS knowledge amongst a population of previously NIHSS-trained HCPs with heterogenous levels of experience and expertise. Previous studies have shown a positive impact on knowledge acquisition amongst NIHSS-naïve paramedics and medical students [22,23]. However, this is the first study to show similar results in HCPs with prior NIHSS knowledge.

Decline in knowledge retention has been shown to be non-linear, with a high percentage of decline measurable after only four weeks of acquisition [29]. Not only does a highly interactive e-learning module improve knowledge acquisition but also has a significant impact on knowledge retention.

Compared to previous studies in NIHSS-naive populations, the overall scores of NIHSS knowledge are slightly higher in this study. However, these scores are lower than could be expected given the specific study population of HCPs with prior NIHSS knowledge using the scale on a regular basis. Several hypotheses could explain this finding. First, baseline data analysis shows that 15% of participants declare themselves uncomfortable with the application of NIHSS, 26% consider themselves as having limited NIHSS knowledge, and only 7 participants have followed the official NIHSS training and certification. Furthermore, only about half the HCPs participating in this study declare having been through the internal training program of their institution. These low numbers could partly be explained by a high turnover currently seen in HCPs in general since the COVID-19 pandemic [30,31], with many new staff members who might have recently started working in these units as reflected by the low number of years the participants have been in their service. Moreover, some of the participants, such as ICU HCPs and emergency ward nurses, may have less exposure to NIHSS usage in their daily practice. Further studies should investigate the association between self-assessed level of NIHSS expertise, frequency of exposition to the score, with the actual NIHSS knowledge.

Access to the official NIHSS training and certification could be limited by financial constraints and linguistic barriers, as most participating HCPs are French speaking. Some advantages of this e-learning module are its free access, the asynchronous learning particularly adapted to HCPs, the possibility to easily translate it into different languages and update chapters individually enabling quick updates if needed in the future. All these points allow easier dissemination of NIHSS knowledge and skills through e-learning than with the traditional didactic English video alone.

The videos used for the quiz could also have an impact on the overall scores. A previous study [23], using the first edition of the e-learning module, had shown that the lack of video extracts, or graphic examples of neurological deficits, decreased the performance of candidates for certain chapters. An

updated version integrating the missing video extracts showed that the performance of the same chapters improved [22]. However, feedback from previous study participants and discussions with experts correlate to say that some of the video excerpts in the e-learning or in the quiz could contain some ambiguity and leave room for some interpretation, for example due to camera angles. We believe that this could in part explain incorrect scoring and thus reduce the overall scores, and that replacing the videos with animated models demonstrating the neurological deficits more clearly could improve overall performance at testing.

Strengths and limitations

Attrition rates, as anticipated, were high in both groups. This is probably related to the fact that the entire study path takes a long time, requiring 4 to 5 hours to be completed, and that there is currently a very high rate of fatigue amongst HCPs [32].

Participants were informed that the study was to be completed individually and without any visual support such as a NIHSS form during the quiz. However, given the web-based asynchronous design of the study, we are unable to verify compliance to these points. The randomization however mitigates this issue, should it hold true.

The improvement of the score at each repetition could be partly induced by a priming effect. However, this effect is similar across both groups and therefore should not induce any bias in data interpretation.

Because language proficiency could have an impact on learning performance, participants were asked about their levels of English and French in the initial demographic questionnaire. Although randomization was intended to guarantee an equal balance of these elements in each group, the comparison allowed us to ascertain it.

Above all, trying to determine NIHSS knowledge by using a 50-question quiz cannot be considered as fully representative of the skills in clinical application of the score. However, this method has been used for the previous two decades in multiple studies testing NIHSS competency. Its usage can therefore be considered as valid to compare multiple learning methods.

Our study also has several strengths. To our knowledge, this is the first paper which assesses the impact of an e-learning method on a population of previously trained-HCPs, in terms of knowledge acquisition and retention. The protocol was published before starting this study, and deviations from the protocol have been thoroughly detailed in this paper. The randomization process was fully automated enabling us to guarantee the concealment of allocation, and data blinding was accomplished at the highest standard. Data was reanalysed to ensure that the elapsed time between the second and third quiz was indeed more than one month, thus ensuring compliance with the protocol.

CONCLUSION

A highly interactive e-learning module was found to be an effective asynchronous method to improve NIHSS knowledge acquisition and retention, notably in previously NIHSS-trained HCPs. It should therefore be integrated into HCPs NIHSS training programs.

ACKNOWLEDGEMENTS

xxx.

CONFLICT OF INTERESTS

None declared

ABBREVIATIONS

CHERRIES	Checklist for Reporting Results of Internet E-Surveys
CHUV	Lausanne University Hospital
CONSORT	Consolidated Standards of Reporting Trials
COVID-19	Coronavirus disease 2019
e-Health	electronic Health
E-learning	Electronic learning
ED	Emergency division
GDPR	General Data Protection Regulation
HCPs	Health Care Professionals
HDU	High dependency unit
HFR	Cantonal Hospital Fribourg
HUG	University Hospital Geneva
ICU	Intensive care unit
NIHSS	National Institutes of Health Stroke Scale
PHP	PHP Hypertext Preprocessor

BIBLIOGRAPHY

1. GBD 2019 Stroke Collaborators. Global, regional, and national burden of stroke and its risk factors, 1990-2019: A systematic analysis for the Global Burden of Disease Study 2019. Lancet Neurol Elsevier Ltd; 2021 Oct 1;20(10):1–26. PMID:34487721
2. Donkor ES. Epidemiology, and Quality of Life. 2018; doi: 10.1155/2018/3238165
3. Powers WJ, Rabinstein AA, Ackerson T, Adeoye OM, Bambakidis NC, Becker K, Biller J, Brown M, Demaerschalk BM, Hoh B, Jauch EC, Kidwell CS, Leslie-Mazwi TM, Ovbiagele B, Scott PA, Sheth KN, Southerland AM, Summers D V., Tirschwell DL. 2018 Guidelines for the Early Management of Patients With Acute Ischemic Stroke: A Guideline for Healthcare Professionals From the American Heart Association/American Stroke Association. Stroke Stroke; 2018 Mar 1;49(3):e46–e110. PMID:29367334
4. Langhorne P. The Stroke Unit Story: Where Have We Been and Where Are We Going? Cerebrovasc Dis Cerebrovasc Dis; 2021 Dec 1;50(6):636–643. PMID:34547746
5. Lyden P. Using the National Institutes of Health Stroke Scale. Stroke 2017 Feb;48(2):513–519. PMID:28077454
6. Tissue plasminogen activator for acute ischemic stroke. N Engl J Med N Engl J Med; 1995 Dec 14;333(24):1581–1588. PMID:7477192
7. Hinkle JL. Reliability and validity of the National Institutes of Health Stroke Scale for neuroscience nurses. Stroke; a journal of cerebral circulation Lippincott Williams & Wilkins Hagerstown, MD ; 2014;45(3). PMID:24496393
8. Dewey HM, Donnan GA, Freeman EJ, Sharples CM, Macdonell RAL, McNeil JJ, G.thrift A. Interrater reliability of the National Institutes of Health Stroke Scale: Rating by neurologists and nurses in a community-based stroke incidence study. Cerebrovascular Diseases 1999 Nov;9(6):323–327. PMID:10545689
9. Schmulling S, Grond M, Rudolf J, Kiencke P. Training as a prerequisite for reliable use of NIH stroke scale [6]. Stroke Lippincott Williams and Wilkins; 1998;29(6):1258–1259. PMID:9626306
10. André C. The NIH Stroke Scale is unreliable in untrained hands. Journal of Stroke and Cerebrovascular Diseases W.B. Saunders; 2002;11(1):43–46. doi: 10.1053/JSCD.2002.123974
11. Lyden P, Raman R, Liu L, Grotta J, Broderick J, Olson S, Shaw S, Spilker J, Meyer B, Emr M, Warren M, Marler J. NIHSS training and certification using a new digital video disk is reliable. Stroke Lippincott Williams and Wilkins; 2005;36(11):2446–2449. PMID:16224093
12. Lyden P, Brott T, Tilley B, Welch KMA, Mascha EJ, Levine S, Haley EC, Grotta J, Marler J. Improved reliability of the NIH stroke scale using video training. Stroke 1994;25(11):2220–2226. PMID:7974549
13. Lyden P. NIH Stroke Scale Training - Part 2 - Basic Instruction.
14. Lyden P, Brott T, Tilley B, Welch KM, Mascha EJ, Levine S, Haley EC, Grotta J, Marler J. Improved reliability of the NIH Stroke Scale using video training. NINDS TPA Stroke Study Group. Stroke 1994 Nov;25(11):2220–6. PMID:7974549
15. Swiss Federation of Clinical Neuro-Societies. Critères de qualité pour la certification des Stroke Centers. Available from: https://sfcns.ch/certification/stroke/re-certification [accessed Jan 30, 2024]
16. Organe de décision MHS. Décision concernant la planification de la médecine hautement spécialisée (MHS) dans le domaine du traitement des accidents vasculaires cérébraux. 2011. Available from: https://www.gdk-cds.ch/fileadmin/docs/public/gdk/themen/hsm/hsm_spitalliste/bb_dc_stroke_praez_20110520_def_f.pdf [accessed Feb 21, 2024]
17. Lyrer P, Engelter S, Gralla J, Andrea Humm P, Fandino J, Fischer U, Pargger H, Z'Graggen W, Georg Kägi P, Luft A, Nedeltchev K, Steudter* E, Schaad H, Carlo Cereda P, Wetzel S, Schwegler G, Mösinger* D, Nowak B, Carrera E, Stippich C, Bonati L, Arnold M, Michel P, Susanne Renaud: P. Stroke Units et Stroke Centers en Suisse. Forum Médical Suisse – Swiss Medical Forum 2024 Feb 7;

doi: 10.4414/fms.2024.1343858063
18. KJ K, G K. Development of e-learning in medical education: 10 years' experience of Korean medical schools. Korean J Med Educ Korean J Med Educ; 2019 Sep 1;31(3):205–214. PMID:31455050
19. Suppan M, Abbas M, Catho G, Stuby L, Regard S, Achab S, Harbarth S, Suppan L. Impact of a Serious Game (Escape COVID-19) on the Intention to Change COVID-19 Control Practices Among Employees of Long-term Care Facilities: Web-Based Randomized Controlled Trial. J Med Internet Res 2021 Mar 25;23(3):e27443. doi: 10.2196/27443
20. Suppan L, Abbas M, Stuby L, Cottet P, Larribau R, Golay E, Iten A, Harbarth S, Gartner B, Suppan M. Effect of an E-Learning Module on Personal Protective Equipment Proficiency Among Prehospital Personnel: Web-Based Randomized Controlled Trial. J Med Internet Res 2020 Aug 21;22(8):e21265. doi: 10.2196/21265
21. Stuby L, Koka A, Suppan L, Suppan M. NIHSS E-learning module 21c - https://nihss-study.ch/e-learning. Available from: https://nihss-study.ch/e-learning [accessed Nov 12, 2023]
22. Suppan M, Stuby L, Carrera E, Cottet P, Koka A, Assal F, Savoldelli GL, Suppan L. Asynchronous Distance Learning of the National Institutes of Health Stroke Scale During the COVID-19 Pandemic (E-Learning vs Video): Randomized Controlled Trial. J Med Internet Res 2021 Jan;23(1):e23594. doi: 10.2196/23594
23. Koka A, Suppan L, Cottet P, Carrera E, Stuby L, Suppan M. Teaching the national institutes of health stroke scale to paramedics (E-Learning vs Video): Randomized controlled trial. J Med Internet Res 2020;22(6). doi: 10.2196/18358
24. Eysenbach G, CONSORT-EHEALTH Group. CONSORT-EHEALTH: improving and standardizing evaluation reports of Web-based and mobile health interventions. J Med Internet Res 2011 Dec;13(4):e126. PMID:22209829
25. Eysenbach G. Improving the quality of Web surveys: the Checklist for Reporting Results of Internet E-Surveys (CHERRIES). J Med Internet Res 2004;6(3):e34. PMID:15471760
26. Koka A, Suppan M, Carrera E, Fraga-Freijeiro P, Massuk K, Imbeault M-E, Missilier Perruzzo N, Achab S, Salerno A, Strambo D, Michel P, Stuby L, Suppan L. Knowledge Retention of the NIH Stroke Scale among Stroke Unit Health Care Workers Using Video vs. E-Learning: Protocol for a Web-Based, Randomized Controlled Trial. Healthcare (Basel) 2021 Oct 28;9(11). PMID:34828505
27. Corejoomla. Community Surveys Pro. 2020;
28. Suppan M, Stuby L, Koka A, Suppan L. NIHSS Video subtitled in french. 2019. Available from: https://nihss-study.ch/video [accessed Jun 21, 2021]
29. Kamuche FU, Ledman RE. Relationship of Time and Learning Retention. Journal of College Teaching & Learning (TLC) Clute Institute; 2005 Aug 1;2(8):25. doi: 10.19030/tlc.v2i8.1851
30. Luo M, Guo L, Yu M, Jiang W, Wang H. The psychological and mental impact of coronavirus disease 2019 (COVID-19) on medical staff and general public - A systematic review and meta-analysis. Psychiatry Res 2020 Sep;291:113190. PMID:32563745
31. Raso R, Fitzpatrick JJ, Masick K. Nurses' Intent to Leave their Position and the Profession During the COVID-19 Pandemic. J Nurs Adm 2021 Oct 1;51(10):488–494. PMID:34519700
32. Zou X, Liu S, Li J, Chen W, Ye J, Yang Y, Zhou F, Ling L. Factors Associated With Healthcare Workers' Insomnia Symptoms and Fatigue in the Fight Against COVID-19, and the Role of Organizational Support. Front Psychiatry 2021 Mar;12. doi: 10.3389/fpsyt.2021.652717

MULTIMEDIA APPENDIX

Multimedia Appendix 1: First Questionnaire

Page	Field	Original Question	English Translation
1	Demographics	Age	Age [a]
		Genre	Gender [b]
		Années d'expérience clinique au total	Number of years of total clinical experience [a]
		Années d'expérience clinique dans un service de neurologie et/ ou de neurochirurgie	Number of years of clinical experience in a neurology and/or neurosurgery ward [a]
		Maîtrise du Français	French proficiency [c]
		Maîtrise de l'Anglais	English proficiency [c]
		Dans quel service travaillez-vous principalement: • Unité Cérébrovasculaire—surveillance continue • Unité Cérébrovasculaire-étage • Etage de neurologie • Soins intermédiaires de neurologie • Etage de neurochirurgie • Soins intermédiaires de neurochirurgie • Autre	In which ward do you most frequently work: [b] • Stroke unit-surveillance unit • Stroke unit-regular ward • Neurology ward • Neurology intermediate care unit • Neurosurgical ward • Neurosurgical intermediate care unit • Other
2	Prior NIHSS knowledge	Avez-vous effectué une formation interne du service pour apprendre à faire une évaluation NIHSS ?	Have you completed an in house NIHSS training? [b]
		Avez-vous complété une formation certifiante officielle NIHSS ?	Have you completed the official NIHSS certification course? [b]
		Nombre d'années de pratique avec l'échelle NIHSS	Number of years of clinical experience with the NIHSS scale [a]
		Fréquence d'application du NIHSS: • Plusieurs fois par jour • Environ 1 fois par jour • Environ 1 fois par semaine • Environ 1 fois par mois	NIHSS use frequency: [b] • Many times per day • Circa once a day • Circa once a week • Circa once per month

	• Très rarement ou jamais	• Almost never or never
	Je me sens à l'aise par rapport à l'application du NIHSS	I feel comfortable using the NIHSS [c]

[a] Regex: regular expression validation. [b] MCQ: multiple-choice question (only one answer accepted). [c] 5-point Likert scale.

Multimedia Appendix 2: Satisfaction Survey questionnaire

Page	Field	Original Question	English Translation
	Feedback regarding training	Avez-vous déjà suivi cette méthode de formation au NIHSS ? • Oui • Non	Have you previously completed this NIHSS learning method? • Yes • No
		Quand avez-vous suivi cette formation ? • Il y a moins d'un mois • Il y a moins de 6mois • Il y a moins d'un an • Il y a plus d'un an • Je ne me souviens pas	When did you complete this training? • Less than a month ago • Less than 6 months ago • Less than a year ago • More than a year ago • I don't remember
		Dans quel cadre avez-vous suivi cette formation ? • Formation demandée par mon service • Trouvé cette formation sur internet par hasard • Information reçue par e-mail	In what context did you undergo this training? • Required by my division • Found this training online by chance • Received information via email
		Comment évaluez-vous le niveau de difficulté global de cette formation ? • Très difficile • Difficile • Intermédiaire • Facile • Très facile	How do you evaluate the level of difficulty of this training? • Very difficult • Difficult • Intermediate • Easy • Very Easy
		Que pensez-vous de la durée de cette méthode de formation ? • Trop longue • Un peu trop longue • Adéquate • Un peu trop courte • Trop courte	What do you think about the duration of this learning method? • Too long • A little too long • Adequate • A little too short • Too short
		Quel est votre niveau de satisfaction concernant la méthode de formation ? • Pas du tout satisfait • Peu satisfait • Neutre / sans opinion • Satisfait	What is your level of satisfaction regarding the learning method? • Not at all satisfied • Not satisfied • Neutral / No opinion • Satisfied • Very satisfied

	• Très satisfait	
	Recommanderiez-vous cette méthode de formation à vos collègues ? • Non-certainement pas • Plutôt non • Pas d'opinion • Plutôt oui • Oui, très probablement	Would you recommend this learning method to your colleagues? • Certainly not • Rather not • No opinion • Rather Yes • Certainly
	Avez-vous des commentaires supplémentaires ? • Texte libre	Do you have any other comments? • Free text

Multimedia Appendix 3: Characteristics of all participants

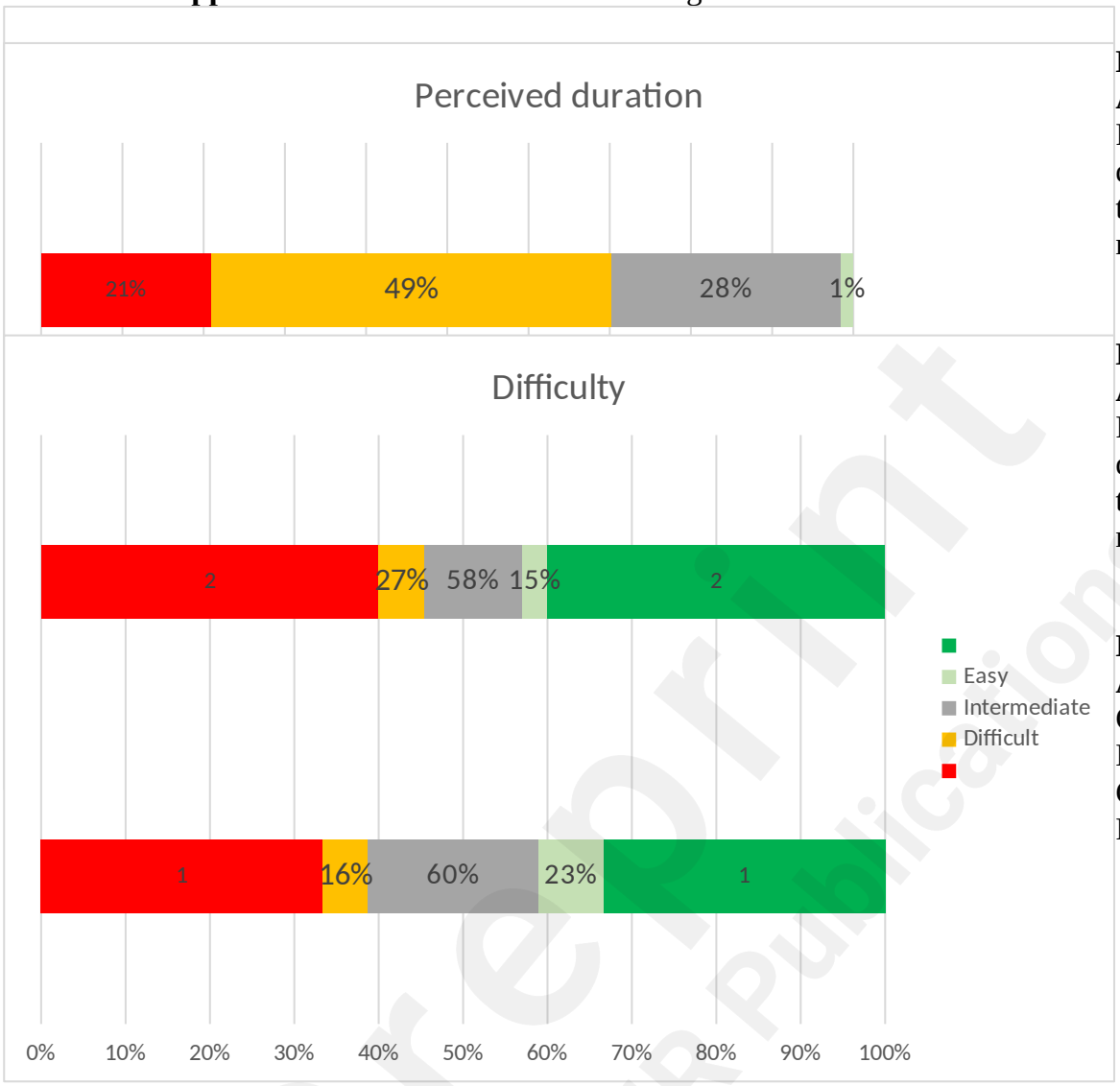
	E-learning (n=43)	**Video (n=67)**	**Randomized to e-learning but did not complete study course (n= 16)**	**Randomized to video but did not complete study course (n= 48)**
Age, years, median [quartiles]	32 [27;41]	32 [29;38]	34 [28;40]	32 [30;39]
- Missing data, n			1	6
Gender, n (%)				
- Female	33 (76.7)	52 (77.6)	11 (68.8)	29 (60.4)
- Male	10 (23.3)	15 (22.4)	4 (25.0)	13 (27.1)
- Missing data, n			1 (6.3)	6 (12.5)
Profession, n (%)				
- Nurse	26 (60.5)	49 (73.1)	9 (56.3)	35 (72.9)
- Physician	17 (39.5)	18 (26.9)	7 (43.8)	13 (27.1)
Time since certification, years, median [quartiles]	6 [2;12]	8 [2;13]	8 [2;15]	7 [3;14]
- Missing data, n			1	6
Center, n (%)				
- HUG	13 (30.2)	30 (44.8)	6 (37.5)	17 (35.4)
- CHUV	7 (16.3)	6 (9.0)	3 (18.8)	9 (18.8)
- HFR	23 (53.5)	31 (46.3)	7 (43.8)	22 (45.8)
Service, n (%)				
- Ward	10 (23.3)	11 (16.4)	2 (12.5)	13 (27.1)
- HDU	13 (30.2)	34 (50.8)	6 (37.5)	11 (22.9)
- ICU	0 (0.0)	3 (4.5)	0 (0.0)	2 (4.2)

- ED	13 (30.2)	12 (17.9)	7 (43.8)	13 (27.1)
- Other	7 (16.3)	7 (10.5)	0 (0.0)	3 (6.3)
- Missing data			1 (6.3)	6 (12.5)
Time in main service, years, median [quartiles]	2 [0;5]	3 [1;5]	3 [0;6]	3 [1;6]
- Missing data			1	6
French mastery, n (%)				
- None	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
- Basic	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
- Intermediate	1 (2.3)	0 (0.0)	1 (6.3)	1 (2.1)
- Advanced	3 (7.0)	9 (13.4)	3 (18.8)	3 (6.3)
- Proficient	39 (90.7)	58 (86.6)	11 (68.8)	38 (79.2)
- Missing data			1 (6.3)	6 (12.5)
English mastery, n (%)				
- None	3 (7.0)	4 (6.0)	0 (0.0)	0 (0.0)
- Basic	10 (23.3)	25 (37.3)	3 (18.8)	15 (31.2)
- Intermediate	12 (27.9)	24 (35.8)	5 (31.3)	19 (39.6)
- Advanced	17 (39.5)	14 (20.9)	6 (37.5)	4 (8.3)
- Proficient	1 (2.3)	0 (0.0)	1 (6.3)	4 (8.3)
- Missing data			1 (6.3)	6 (12.5)
NIHSS internal training, n (%)	19 (44.2)	38 (56.7)	9 (56.3)	11 (22.9)
- Missing data			1 (6.3)	6 (12.5)
NIHSS official training, n (%)	2 (4.7)	5 (7.5)	1 (6.3)	4 (8.3)

- Missing data			1 (6.3)	6 (12.5)
Time since NIHSS use, years, median [quartiles]	3 [1;7]	3 [1;5]	4 [2;6]	3 [1;6]
- Missing data, n			1	6
NIHSS use frequency, n (%)				
- <1 / month	6 (14.0)	3 (4.5)	1 (6.3)	5 (10.4)
- 1x / month	7 (16.3)	10 (14.9)	1 (6.3)	4 (8.3)
- 1x / week	8 (18.6)	14 (20.9)	2 (12.5)	6 (12.5)
- 1x / day	6 (14.0)	8 (11.9)	2 (12.5)	11 (22.9)
- >1x / day	16 (37.2)	32 (47.8)	9 (56.3)	16 (33.3)
- Missing data			1 (6.3)	6 (12.5)
Comfort with NIHSS use, n (%)				
- Not comfortable at all	3 (7.0)	1 (1.5)	2 (12.5)	3 (6.3)
- Not so comfortable	7 (16.3)	6 (9.0)	2 (12.5)	5 (10.4)
- Moderately comfortable	13 (30.2)	17 (25.4)	3 (18.8)	14 (29.2)
- Quite comfortable	15 (34.9)	32 (47.8)	7 (43.8)	18 (37.5)
- Very comfortable	5 (11.6)	11 (16.4)	1 (6.3)	2 (4.2)
- Missing data			1 (6.3)	6 (12.5)
NIHSS expertise, n (%)				
- Limited	14 (32.6)	15 (22.4)	3 (18.8)	10 (20.8)
- Moderate	20 (46.5)	22 (32.8)	5 (31.3)	21 (43.8)
- Extended	9 (20.9)	30 (44.8)	8 (50.0)	17 (35.4)

Total may not be exactly 100% due to rounding

Multimedia Appendix 4: User satisfaction of learning method



Multimedia Appendix 5: Perceived duration of the learning method.

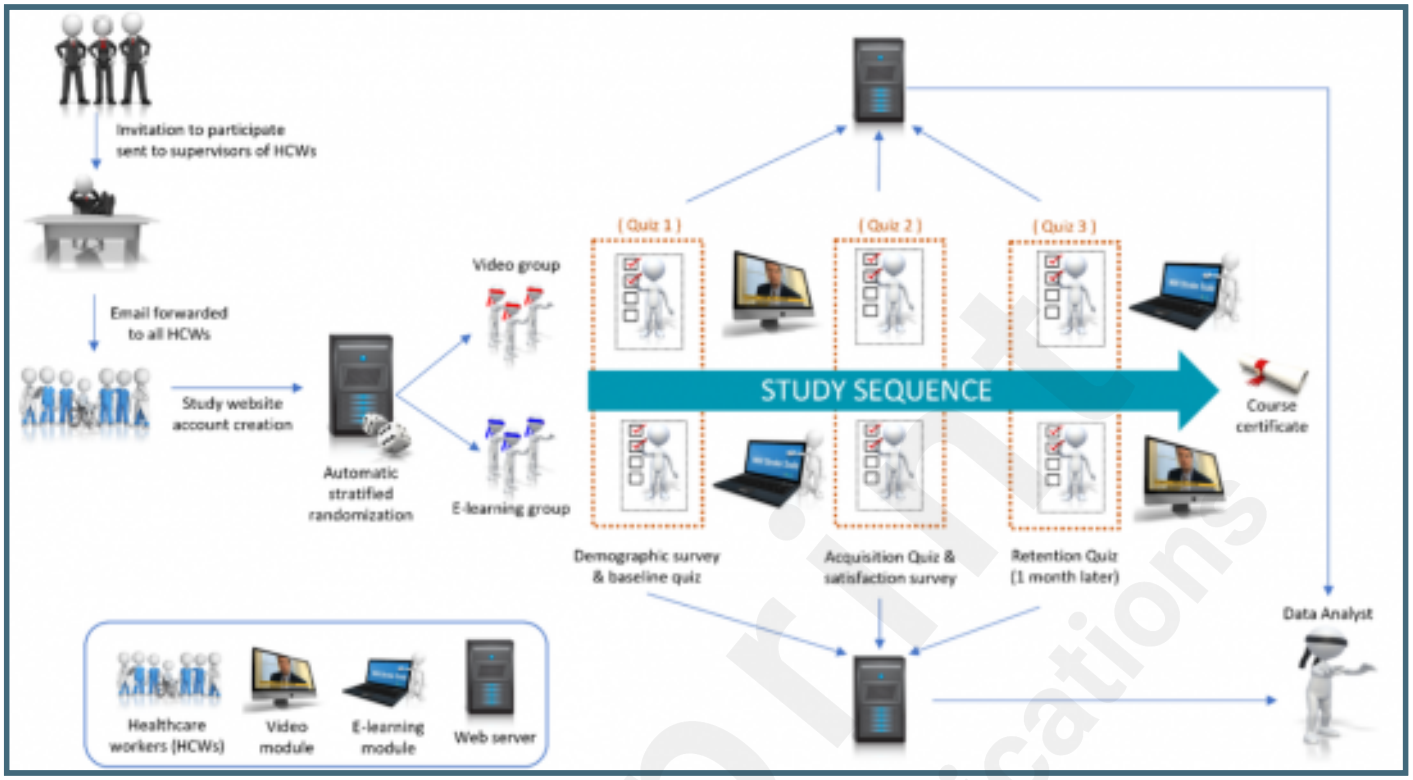
Multimedia Appendix 6: Perceived difficulty of the learning method.

Multimedia Appendix 7: CONSORT-EHEALTH Checklist. Please see supplementary file entitled “CONSORT-EHEALTH V1.6”

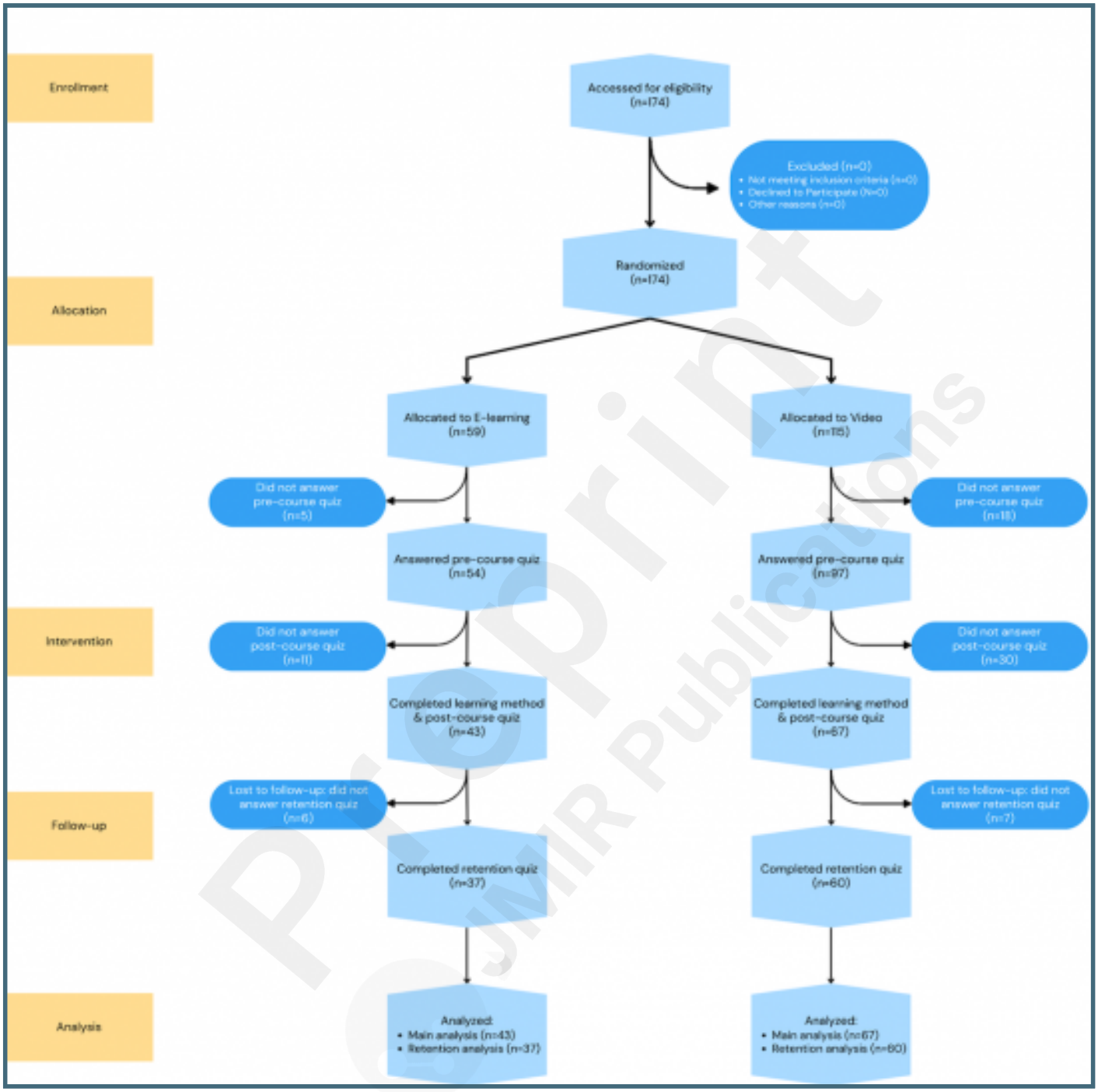
Supplementary Files

Figures

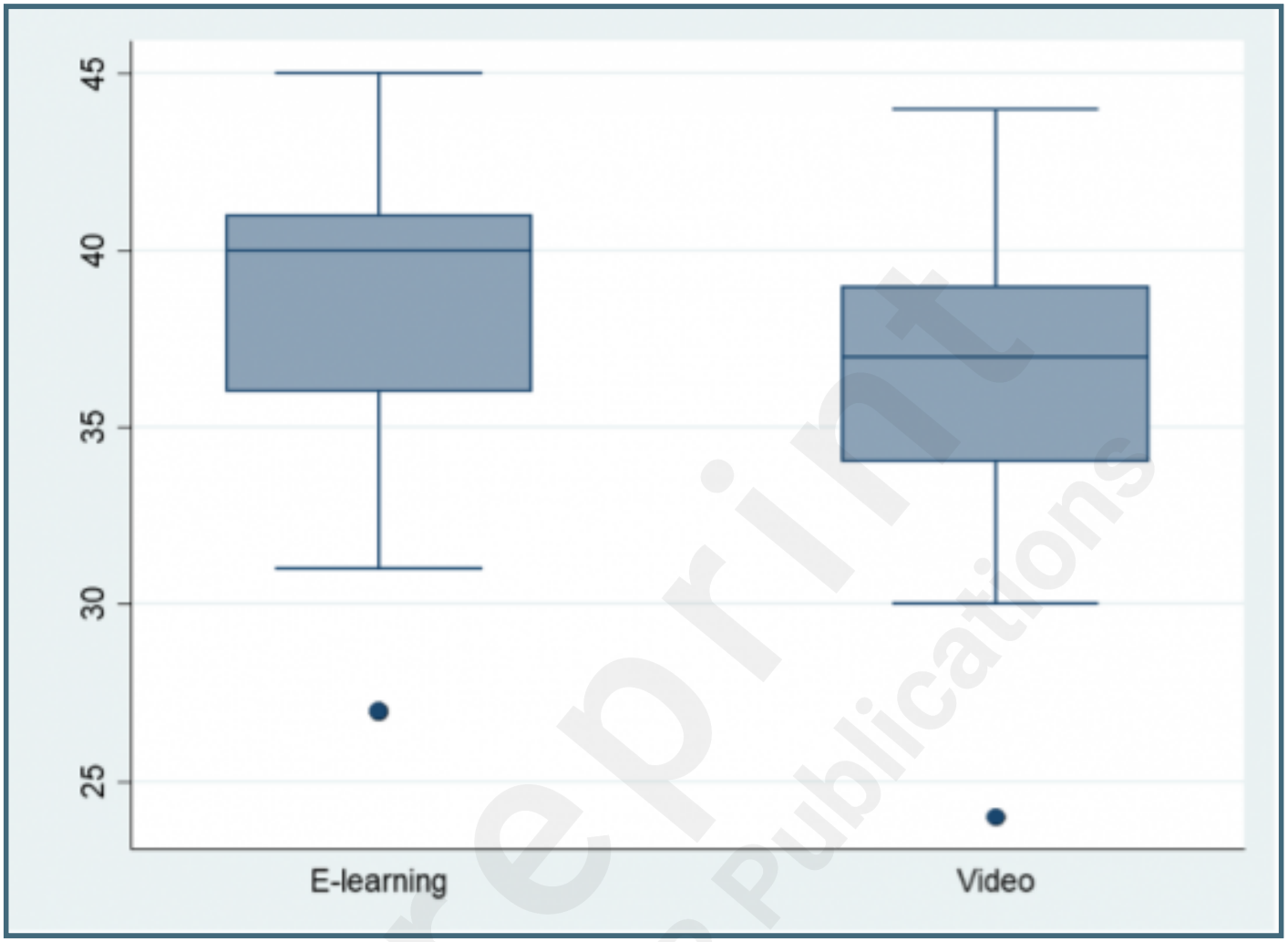
Study design.



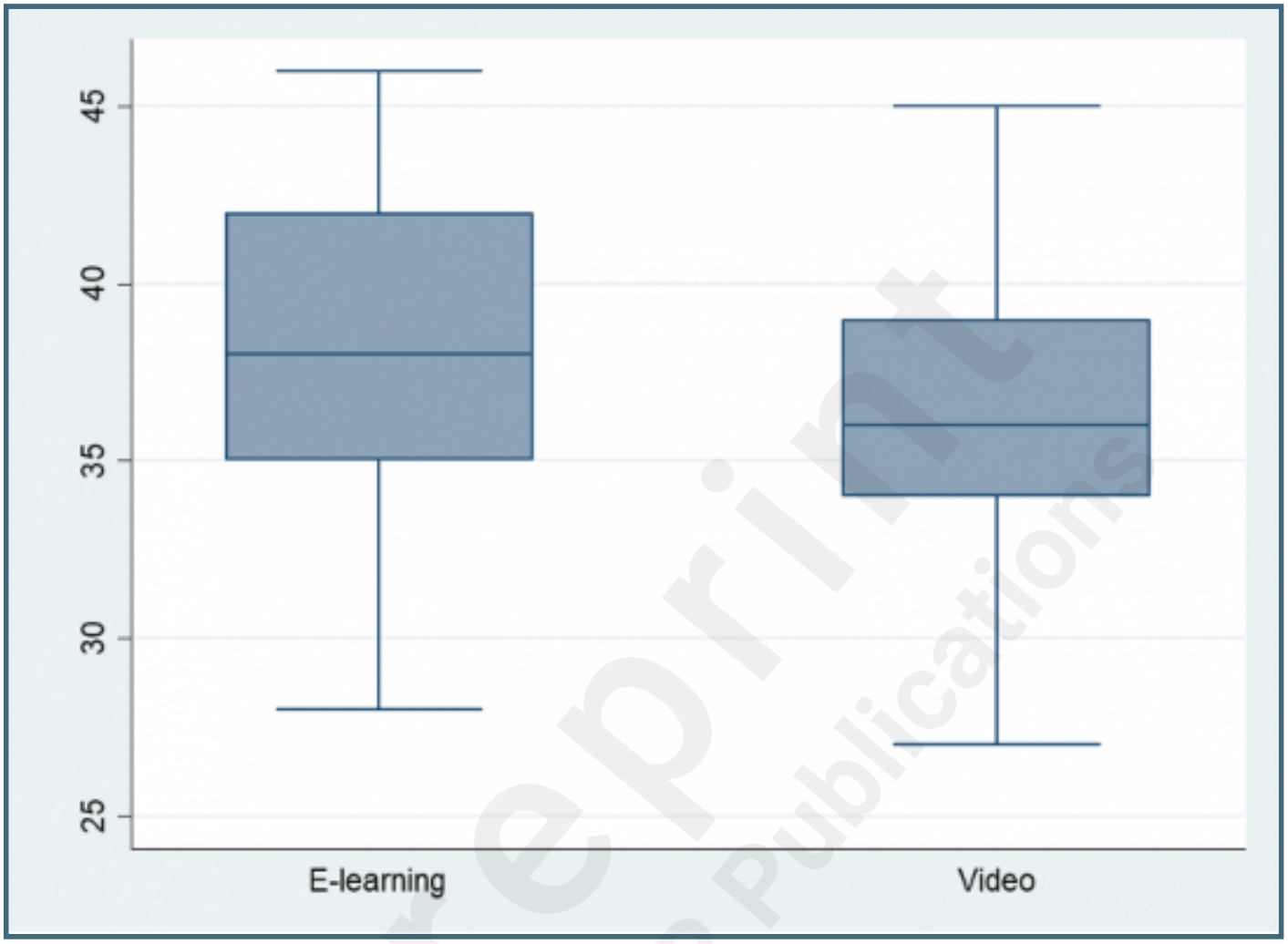
CONSORT flowchart.



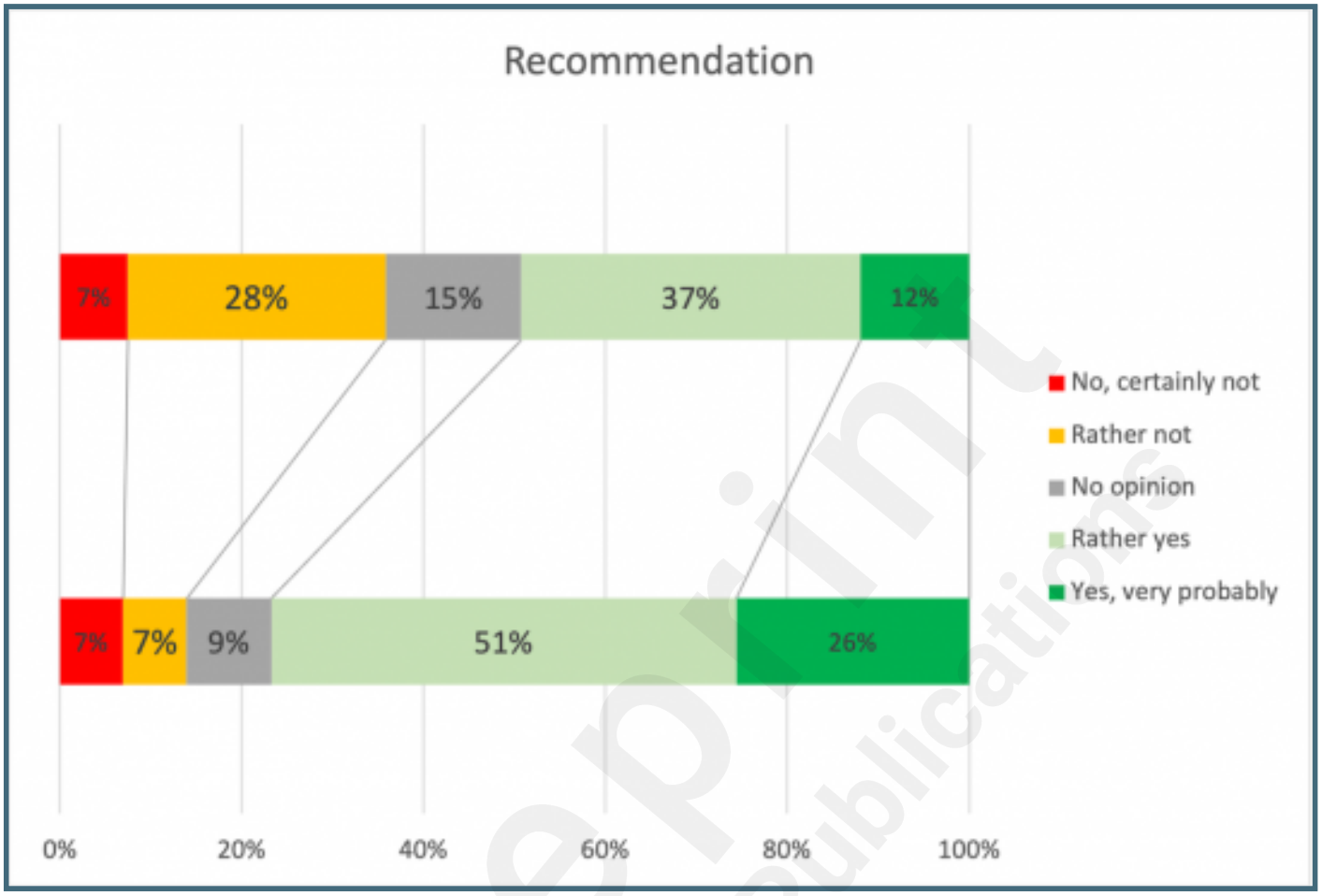
NIHSS knowledge acquisition quiz (quiz 2) among groups.



NIHSS knowledge retention quiz (quiz 3) among groups.



Likelihood of recommending the learning method to a colleague.



Multimedia Appendixes

First questionnaire.
URL: http://asset.jmir.pub/assets/48db380d64f1ee71fe88cf5120899d1d.doc

Satisfaction Survey questionnaire.
URL: http://asset.jmir.pub/assets/1cbe94bc1eff76370bc879b8238fcbbf.doc

Characteristics of all participants.
URL: http://asset.jmir.pub/assets/7364d3a9dd26bfc90968e7f7a92a5809.doc

User satisfaction of learning method.
URL: http://asset.jmir.pub/assets/9d5b30056599f4122fe7bc2527069a86.png

Perceived duration of the learning method.
URL: http://asset.jmir.pub/assets/ed8e9aa06fac74c39938832c78d70eba.png

Perceived difficulty of the learning method.
URL: http://asset.jmir.pub/assets/096396ccfc4e1cd95c428fb9c59e2bd3.png

CONSORT-EHEALTH checklist V 1.6.
URL: http://asset.jmir.pub/assets/a6ccde52b2f2331454aa5ae190d6ea95.pdf

CONSORT (or other) checklists

Consort checklist for RCT publications.
URL: http://asset.jmir.pub/assets/556c37d7940aa31ba6044a34d3729769.pdf