Preventive Medicine Reports 53 (2025) 103049

Contents lists available at ScienceDirect

Preventive Medicine Reports

journal homepage: www.elsevier.com/locate/pmedr

Enhancing stroke response in school children: Efficacy of the HOBIT program - a cluster randomized trial

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ARTICLE INFO

Keywords:
Cluster randomized trial
School
Children
Intervention
Stroke awareness
Health education

ABSTRACT

Objective: Stroke treatment is often hampered by delayed Emergency Medical Services activation. Public campaigns to improve the response to stroke symptoms are either costly or not working. We evaluate the effectiveness of a school-based HOBIT program in improving Emergency Medical Services activation.

Methods: This cluster randomized trial was conducted from May to June 2023 at 13 schools in the South Moravian region of Czechia. Schools were randomized to the HOBIT intervention or control group with a 3:1 ratio. Both groups had knowledge assessments at baseline and follow-up. The primary outcome was the percentage change from the pretest to the follow-up test in the intervention group compared to the control group in 4 domains: 1) knowledge, 2) self-efficacy, 3) outcome expectations, 4) behavioral intentions.

Results: The baseline knowledge was greater than 50 % in most metrics except for knowledge of the FAST test, which was only 16 %. The intervention effect was 16 % (95 % CI 12–21) for knowledge, 10 % (95 % CI 4–15) for self-efficacy,10 % (95 % CI 5–15) for outcome expectations, 8 % (95 % CI 2–11) for behavioral intentions.

Conclusions: In school children, even those with high baseline, "HOBIT" intervention can improve determinants and behavioral intentions of Emergency Medical Services activation for suspected stroke.

1. Introduction

Stroke continues to be a leading global cause of mortality, contributing to more than six and a half million deaths annually worldwide (Feigin et al., 2022). For treatment to be effective, it must be given as soon as possible after stroke onset (Mikulík et al., 2022). However, fewer than 10 % of stroke patients reach the hospital within 60 min after symptom onset (Norrving et al., 2018). Delays are often caused by stroke victims or bystanders failing to quickly recognize stroke symptoms and properly activate emergency medical services (EMS) (Seo et al., 2021; Teuschl and Brainin, 2010; Faiz et al., 2013).

To address the above challenge, educational campaigns to inform the public about stroke recognition and response have been implemented across the United States, Canada, Japan, and some European countries, such as the United Kingdom, Ireland, Sweden, and Germany (Tan et al., 2022). They demonstrated a 20 % improvement in stroke symptom awareness, measured as a relative risk based on pre- and post-intervention comparisons in a meta-analysis. However, educational campaigns effectiveness depends strongly on the intensity of the funding and often has a short-term effect (Bray et al., 2015; Mellon et al., 2014; Nishijima et al., 2017; Masztalewicz et al., 2016). One possible solution could be shifting stroke education to the school setting. Integrating into the curriculum could allow the programs to be implemented continuously without involving outside experts and additional funding. School-based programs have been developed in Nigeria, China, Japan, America, Italy, Portugal, and Turkey (Di Carlo et al., 2023; Komolafe et al., 2020; Marto et al., 2017; Tekyol et al., 2023; Ohyama et al., 2015; Li et al., 2020; Williams et al., 2018). Systematic reviews of stroke school-based programs show that they can potentially increase the number of individuals capable of recognizing stroke and transferring knowledge to other community members (Beal et al., 2016; Boden-Albala and Quarles, 2013; Ottawa et al., 2015). Despite their proven efficacy in improving stroke awareness, these interventions often focus on improving knowledge, omitting other crucial factors influencing EMS activation decisions, like self-efficacy, outcome expectations, and social norms (Beal et al., 2016). This goes against preventive medicine's emphasis on the behavioral change approach (Lahariya, 2024). Also, challenges persist in their implementation, particularly in ensuring long-term integration into curricula and addressing gaps in health promotion, as evidenced by fragmented school health programs (Jakasania et al., 2023).

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https://doi.org/10.1016/j.pmedr.2025.103049
Received 8 November 2024; Received in revised form 21 March 2025; Accepted 22 March 2025
Available online 1 April 2025

In response to this gap, we developed a new version of the "HOBIT" program ("HOdina BIologie pro živoT", meaning "Biology Lesson for Life")—the stroke school-based program for secondary schools aimed at knowledge, risk perception, outcome expectation, and skills—as the main determinants of correct EMS activation in suspected stroke patients. The initial version of the HOBIT intervention was developed in 2014 as a response to low stroke awareness in the general population and the insufficient effectiveness of population-wide mass media campaigns in Czechia (Vondráčková and Mikulík, 2017). The updated version was developed in November 2022 and became available after the end of the current research project to avoid contamination bias in the control group. This study aimed to evaluate the efficacy of the new version of HOBIT to improve stroke EMS activation in secondary school children. We hypothesized that compared with students in the control group, those in the intervention group would have improved stroke knowledge, risk perception, outcome expectations, self-efficacy, and behavioral intentions.

2. Materials and methods

This parallel two-arm cluster randomized controlled trial was conducted at secondary schools (years 7, 8, and 9) between May 2023 and June 2023 in the South Moravian region of Czechia. This pragmatic trial was conducted in settings similar to the "real world." It included adopting school settings, teacher-led delivery during classroom time, no strict exclusion criteria for students, integrating the program into the curriculum, and selecting data collection time points to align with school academic calendars.

2.1. Participants and randomization procedure

The Ministry of Education, Youth, and Sport statistics were used as a sample frame to create a list of eligible schools. Schools were eligible if they were 1) private or state primary schools and college-preparatory schools that provide lower secondary education or 2) able to include a minimum of two classes (maximum five) per school. Special and non-traditional schools were not eligible for the study (e.g., at the hospital, for the medically disadvantaged, with speech therapy, at the diagnostic institute, specialized school, Waldorf school, forest schools, schools in socially excluded locations, Montessori schools). Within schools, classes were eligible if they never participated in the HOBIT program. Schools were invited to participate via email and mobile calls (for those who did not answer email invitations).

We contacted all 246 eligible schools, including 29 private schools, in the South Moravian region of Czechia. The number of private schools corresponds to the distribution of the private schools in Czechia, which is 15 %. Altogether, 36 schools agreed to participate in the project, all public. Eighteen of 36 schools were randomly allocated to the present study by the first author using a computer-generated block randomization list. The remaining 18 schools were allocated to another project led by the research team and run in parallel with the current project due to the project's reasons. This second project tested the efficacy of a school-based program to improve recognition and reaction to panic attacks.

Eighteen schools were then sequentially allocated to the intervention or control groups with a 2:1 ratio by the first author randomized schools via a computer-generated block randomization list. After randomization, teachers were informed about their school group status and had to register classes at the e-learning portal. Since this was a pragmatic trial, it was part of the lesson and the learning process. Therefore, the participation of all students in a particular class was expected.

2.2. Intervention

The HOBIT is a school-based educational program aimed at improving the appropriate activation of the EMS by children when stroke is suspected in their surroundings. It consists of two 45-min educational sessions and includes interventional and assessment parts. The first session is a computer class consisting of e-learning with an educational film and a pretest-posttest structure. The second session take place one week after the first session and includes teacher-led work with worksheets that involved entertainment tasks for repeating information from e-learning.

The primary intervention component, a 5-min educational film, is specifically designed to teach school children how to recognize a stroke, manage a stressful situation, respond appropriately, and, as a result, timely activate the EMS. The film content is grounded in social cognitive theory, emphasizing knowledge, risk perception, outcome expectations, self-efficacy, social influence, and skill as pivotal for behavioral change. Social modeling, a critical method for influencing behavior change, is integrated into the film's entertainment-education format, featuring relatable scenarios and characters to engage and educate the children. The intervention was tailored to children by incorporating age-appropriate storytelling, interactive elements, and scenarios that reflect real-life situations relevant to their everyday experiences that were co-created with target group members. A detailed exposition of the intervention's development was published elsewhere (Volevach et al., 2024).

The secondary component, a worksheet, complements this learning by reviewing and reinforcing the information presented in the film. They were developed by pedagogical experts who specialized in developing educational curricula for school-children and included a variety of individual and group tasks aimed at consolidating the educational content. Before the program started, teachers received free training that included information about stroke and the structure of the intervention. Special video instructions about using the e-learning portal and a technical support line were available on the e-learning website.

2.3. The flow of the study

During the first computer class, students from both groups registered on the e-learning portal and completed the pretest. Students in the intervention group then watched the educational film and completed the immediate posttest. Approximately one week after the e-learning, they received a lesson with additional interactive educational materials led by teachers. Five weeks after pretesting, students from both the intervention and control groups completed the follow-up test at the e-learning portal. As the HOBIT is conceived to be part of the curriculum and is freely available on the website, schools in the control group can undergo the program after the end of the trial. The flow of the study is shown in Fig. 1.

2.4. Outcomes

The primary outcome was the percentage change from the pretest to the follow-up test in the intervention group compared to the control group. The primary outcome was assessed in 4 domains:

1) Knowledge and risk perception
2) Behavior intentions
3) Self-efficacy for stroke recognition and response
4) Stroke outcome expectations.

The secondary outcome was the percentage change from the pretest to the follow-up test in the intervention group compared to the control group for the individual test items.

2.5. Data collection and assessments

Outcomes were assessed using a test consisting of 18 questions. The test instrument was validated through cognitive interviews with four secondary school students and pilot testing at two secondary schools with 88 students aged 10–14. Seven multiple-choice questions on

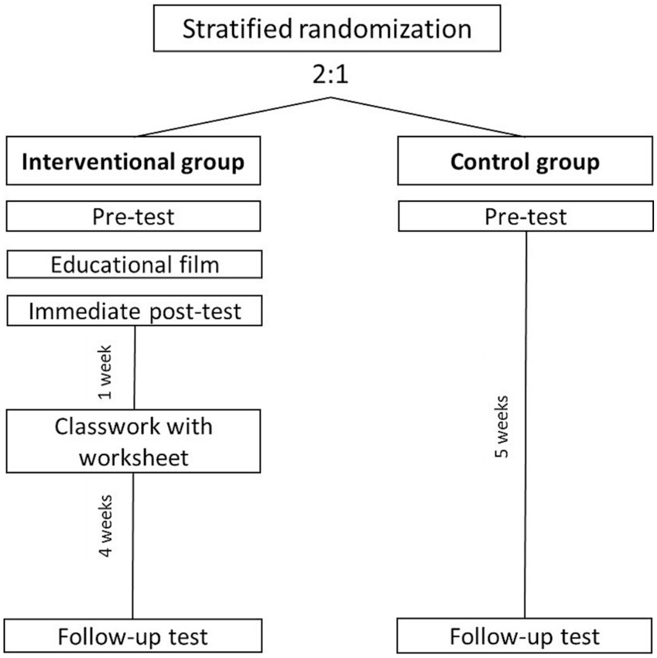

Fig. 1. The flow of the clustered randomized study conducted in Czechia in 2023.

knowledge and risk perception were derived from existing studies and modified for the current study (Sakamoto et al., 2014; Tomari et al., 2017). The outcome expectations and self-efficacy questions were based on Bandura's social learning theory (Bandura, 2006), with specific items derived from earlier studies (Miller et al., 2007; Kandakai and King, 1999). They were measured on a 5-point Likert scale. The reliability of the self-efficacy and outcome expectation scales was measured using the Spearman-Brown coefficient, the most appropriate reliability coefficient for two-item scales (Eisinga et al., 2013). The Spearman-Brown coefficient was 0.4 ($P < 0.001$) for self-efficacy and 0.45 ($P < 0.001$) for outcome expectations, according to the results of the pilot study, with $P \leq 0.05$ considered significant. Table A1 of supplemental materials provides definitions and measures of the above outcome variables.

Behavior intentions were measured using seven 30-s video vignettes simulating stroke or stroke-mimicking scenarios. Video scenarios were drafted and filmed under the supervision of a health promotion specialist and revised by a clinical neurologist. Each vignette was followed by two sub-questions: on stroke recognition (What situation is shown on the video: stroke, other, do not know) and on stroke response (What should the character do: call an ambulance, other reaction, do not know). One point was given for the correct answer to both questions (i.e., recognition and response) belonging to each vignette. A full description of video vignettes, including screenshots, can be found in Table A2 of supplemental materials.

2.6. Power and sample size analysis

A cluster randomized control trial was conducted with two arms (intervention vs. control) and two waves (pretest vs. follow-up). Estimating the effective sample size required adjustment of the total sample size for the cluster design effect by $1 + (M-1)*ICC$ (Higgin and Eldridge, 2023). Assuming a mean of 30 students per school and an intraclass correlation coefficient (ICC) of 0.021 (Kleszczewska et al., 2021), the design effect was 1.61. Using the program G-Power (Faul et al., 2009), the total sample size was calculated with $N = 321$, assuming a small to medium effect size (Cohen's d = 0.30) (Beal et al., 2016) with a significance level of $\alpha = 0.05$ and a power of 0.80. Thus, the calculated sample size was $N = 321*1.61 = 517$ students and 17 schools. Given a 2:1 ratio, we must have allocated 11 schools (335 students) to the intervention group and six schools (182 students) to the control group.

2.7. Statistical analysis

The sample was screened for missing data. Descriptive statistics were used to summarize baseline characteristics of the sample and to assess comparability between the intervention and control groups. Continuous variables were reported as means with 95 % confidence intervals (CIs), and categorical variables as frequencies and percentages.

To evaluate the effect of the HOBIT intervention, absolute percentage changes from baseline (pretest) to follow-up were calculated for each outcome domain: (Feigin et al., 2022) knowledge and risk perception, (Mikulík et al., 2022) behavioral intentions, (Norrving et al., 2018) self-efficacy, and (Seo et al., 2021) outcome expectations. For each group, mean outcome scores at both time points were computed, and within-group differences were derived. The intervention effect was expressed as the between-group difference in these change scores, presented with 95 % CIs. The same analysis was also conducted at the item level for the knowledge and behavioral intention domains.

No formal hypothesis testing was performed, as interpretation was based on the magnitude and precision of effects, reflected in the confidence intervals. All analyses were conducted using IBM SPSS Statistics for Windows, version 23.0 (IBM Corp., Armonk, NY, USA).

2.8. Ethical approval

The research protocol was reviewed as not a human medical research subject and was deemed exempt by St. Anne's Hospital Medical Ethics Committee according to Act No. 378/2007 Coll., which the State Institute for Drug Control (SUKL) implemented and stipulated the need for ethical approval only for clinical trials.

The HOBIT program is an accredited program of the Ministry of Education, Youth and Sports (accreditation number MSMT-15835/2019–1-637) delivered during normal school lessons as part of the curriculum along with the learning outcomes of the intervention. The control group does not involve any alternative intervention and only includes testing with the help of tests approved within the Ministry of Education, Youth and Sports accreditation. Therefore, including in the trial does not carry any risks other than those arising from the normal course of the lesson with the study's interactions with children are educational measures of curriculum implementation, and the remaining activities are observations of public behavior.

Written permission to conduct the study was obtained from school principals. Consent for personal data processing was obtained from the students during the registration on the e-learning portal under Regulation (EU) No. 2016/679 of the European Parliament.

3. Results

3.1. Screening for missing data

Eighteen schools were randomized into intervention and control groups. Attrition after the randomization was one school in the intervention group and three schools in the control groups (see Fig. 2). As a result, students from 13 secondary schools (10 in the intervention group and 3 in the control group) in the South Moravian region of Czechia were included in the current study (see Fig. 2). Five hundred thirty-two students from 13 schools registered for the pretest (452 students in the intervention group and 123 in the control group). The number of students who were eligible for the score calculation was 292 in the intervention group (65 % of all registered students) and 87 in the control group (70 % of all registered students) (see Fig. 2). The reasons for attrition at the student level were absence from school on the day of the testing and incomplete tests. A total of 379 students from 13 schools were included in the analysis.

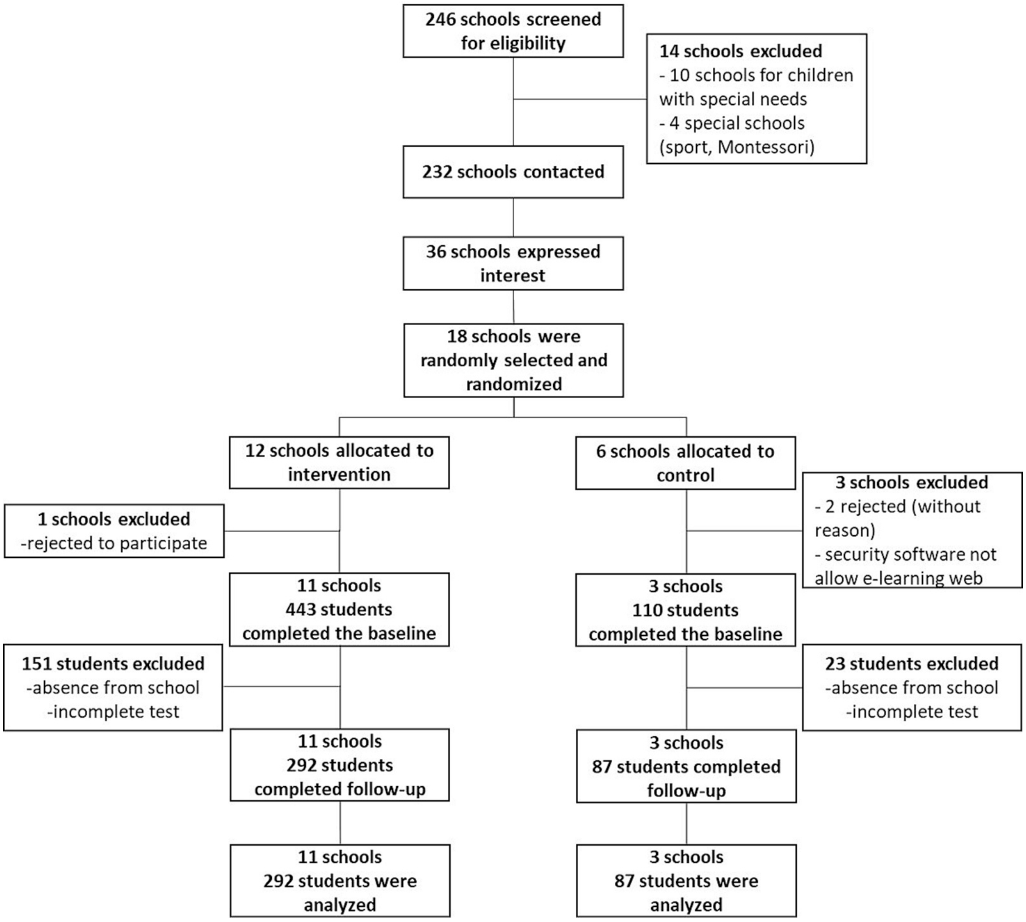

Fig. 2. CONSORT diagram of participant recruitment and flow for study conducted in Czechia in 2023.

3.2. Baseline differences

Baseline characteristics, including demographics and school characteristics, are shown in Table 1. The participants did not differ by age; the control group included slightly more males. Forty-seven percent of the students in the intervention group and 80 % in the control group were in the 8th grade. The intervention and control schools did not differ significantly in the baseline prevalence of the outcome variable (Table 2). The baseline scores did not differ significantly by sex. The mean interval between the pretest and follow-up test was 31 (95 % CI 30.1–31.6) days in the control group and 30 (95 % CI 29.6–30.2) days in the intervention group.

3.3. Primary outcome

The absolute percentage differences in improvement between the control and intervention groups were 16 % (95 % CI 12–21) for knowledge and risk perception, 8 % (95 % CI 2–11) for behavioral intentions, 10 % (95 % CI 4–15) for self-efficacy, and 10 % (95 % CI 5–15) for outcome expectations. In preliminary analysis, no gender differences in intervention effect were found. Therefore, further results are presented without gender adjustment. More detailed results with baseline and follow-up values are shown in Table 2.

Table 1
Baseline students and school characteristics in Czech schools, enrolled in the study in 2023, $n = 379$.

Characteristic	Intervention, $n = 292$	Control, $n = 87$
Gender, female *N (%)*	134 (48)	36 (41)
Age, mean (95 % CI)	13.7 (13.6–13.9)	14.2 (13.5–14.5)
Grade, N (%)		
7	68 (23)	8 (9)
8	137 (47)	70 (80)
9	87 (30)	9 (10)
Students per school, mean (95 % CI)	32 (30.9–32.9)	29 (28.7–30.3)
Classes per school, mean (95 % CI)	2.8 (2.7–2.9)	2.4 (2.3–2.5)
Students per class, mean (95 % CI)	13 (12.5–13.4)	13 (12.5–13.8)

3.4. Secondary outcome

Table 3 shows the percentage of correct answers to the knowledge and risk perception questions. A difference in improvement between the control and intervention groups was found for 7 of 15 items: stroke is a life-threatening disease, FAST method, calling an ambulance, facial drooping, trouble seeing, physical activity, and salty food as risk factors. In other items, a slight insignificant increase was found.

Behavior intentions were measured by five video vignettes with stroke symptoms and two with stroke-mimicking symptoms. Table 4 shows the percentages of correct answers on stroke and stroke mimicking vignettes for the control and intervention groups in the pretest and follow-up tests. The difference in improvement between the control and intervention groups was 8 % (95 % CI 0–15) for stroke vignettes and 8 % (95 % CI -2-19) for stroke-mimicking vignettes.

4. Discussion

In this clustered randomized trial involving students from 13 secondary schools in the South Moravian region (Czechia), we evaluated the efficacy of the HOBIT intervention in improving the determinants and behavioral intentions of EMS activation for suspected stroke in

Table 2
Comparison of the mean percentage of correct answers of Czech students in both groups before and after intervention conducted in 2023, n = 379.

Question Domain	Intervention group (n = 292)			Control group (n = 87)			Diff. between int. and cont. Groups % (95 % CI)
	Pretest % (SD)	Follow-up % (SD)	The absolute difference between the pretest and follow-up test % (95 % CI)	Pretest % (SD)	Follow-up % (SD)	The absolute difference between the pretest and follow-up test % (95 % CI)	
Knowledge and risk perception	59 (19)	83 (15)	25 (22–27)	57 (19)	65 (19)	8 (5–12)	16 (12–21)
Behavior intentions	54 (20)	67 (20)	13 (11–16)	56 (21)	61 (19)	6 (1–10)	8 (2–13)
Self-efficacy	52 (22)	69 (19)	17 (14–20)	54 (22)	62 (20)	8 (3–12)	10 (5–15)
Outcome expectations	85 (17)	90 (17)	4 (2–6)	89 (16)	83 (23)	−5 (−10–−1)	10 (4–15)

Table 3
Comparison of the mean percentage of correct answers of Czech students in both groups before and after intervention each tested items of knowledge domain in 2023, n = 379.

Question Domain	Intervention group (n = 292)			Control group (n = 87)			Diff. between int. and cont. Groups % (95 % CI)
	Pretest % (SD)	Follow-up % (SD)	The absolute difference between the pretest and follow-up test % (95 % CI)	Pretest % (SD)	Follow-up % (SD)	The absolute difference between the pretest and follow-up test % (95 % CI)	
General Knowledge							
Stroke is a life-threatening disease	67 (47)	86 (35)	18 (13–24)	76 (43)	80 (40)	5 (−7–16)	14 (2–25)
Sudden onset is typical for stroke	58 (49)	77 (42)	18 (12–25)	54 (50)	62 (49)	8 (−3–19)	10 (−2–23)
FAST is an identifier for stroke	16 (37)	80 (40)	64 (58–69)	25 (44)	36 (48)	10 (2–18)	53 (42–65)
Call an ambulance	69 (46)	81 (39)	12 (6–18)	71 (46)	67 (47)	−5 (−16–7)	17 (3–30)
Risk perception							
Stroke affects all ages	72 (45)	85 (36)	13 (8–18)	69 (47)	75 (44)	6 (−4–16)	7 (−4–17)
Symptoms							
Facial drooping	60 (49)	91 (29)	30 (24–37)	68 (47)	77 (42)	9 (−1–19)	21 (9–34)
Trouble seeing	36 (48)	81 (39)	46 (39–52)	30 (46)	39 (49)	9 (−3–22)	36 (22–50)
Arm weakness	56 (50)	88 (32)	32 (26–39)	46 (50)	68 (47)	22 (10–34)	10 (−3–24)
Slurred speech	83 (38)	95 (21)	12 (8–17)	86 (35)	90 (31)	3 (−6–13)	9 (−1–19)
Loss of balance	71 (46)	85 (36)	14 (8–20)	61 (49)	69 (47)	8 (−5–21)	6 (−7–19)
Risk factors							
Alcohol	71 (45)	91 (29)	20 (14–25)	69 (47)	82 (39)	13 (1–24)	7 (−5–19)
Hypertension	71 (46)	70 (46)	−1 (−7–6)	64 (48)	70 (46)	6 (−8–2)	−6 (−21–8)
Physical activity	48 (50)	78 (42)	30 (24–37)	30 (46)	46 (50)	16 (4–28)	14 (0–28)
Smoking	55 (50)	81 (39)	26 (19–32)	59 (50)	72 (45)	14 (2–26)	12 (−2–26)
Salty and fatty food	47 (50)	83 (38)	35 (29–42)	41 (50)	43 (50)	1 (−11–14)	34 (21–48)

Table 4
Comparison of the mean percentage of correct answers of Czech students in both groups before and after intervention for each tested item of behavioral intentions domain in 2023, n = 379.

Question Domain	Intervention group (n = 292)			Control group (n = 87)			Diff. between int. and cont. Groups % (95 % CI)
	Pretest (SD)	Follow-up (SD)	The absolute difference between pretest and follow-up test (95 CI)	Pretest (SD)	Follow-up (SD)	The absolute difference between pretest and follow-up test (95 CI)	
Stroke vignettes	56 (29)	74 (28)	18 (15–22)	61 (30)	72 (29)	11 (4–17)	8 (0–15)
Arm weakness	51 (50)	64 (48)	13 (6–19)	59 (50)	66 (48)	7 (−5–19)	6 (−8–19)
Trouble seeing	28 (45)	56 (50)	28 (22–35)	33 (47)	49 (50)	16 (4–28)	12 (−2–26)
Slurred speech	51 (50)	68 (47)	17 (10–23)	56 (50)	74 (44)	17 (5–29)	0 (−14–13)
Face, Arm, Speech (school settings)	77 (42)	93 (26)	16 (11–22)	83 (38)	91 (29)	8 (0–16)	8 (−3–19)
Face, Arm, Speech (home setting)	73 (45)	90 (29)	17 (12–23)	76 (43)	80 (40)	5 (−5–14)	13 (1–24)
Stroke mimicking vignettes	48 (39)	50 (43)	1 (−4–7)	41 (38)	34 (38)	−7 (−16–2)	8 (−2–19)
Mimicking (Face, Arm, Speech – alcohol intoxication)	46 (50)	45(50)	−1 (−7–6)	39 (49)	28 (45)	−11 (−24–1)	11 (−3–25)
Mimicking (Speech – panic attack)	51 (50)	54 (50)	3 (−3–10)	44 (50)	41 (50)	−2 (−15–10)	6 (−8–20)

10–15-year-old children Eighteen schools were randomly allocated to the present study.

Of the 246 eligible schools in the South Moravian region, 36 (15 %) agreed to participate in the project. Given that 64 schools voluntarily implemented HOBIT into their curricula in the South Moravian Region from June to December 2023, the low level of participation is likely due to the research nature of the project, which requires strict adherence to rules and testing schedules. Also, the response rate is standard compared to other research projects in Czechia, according to the statements from the educational experts.

The HOBIT intervention improved knowledge of stroke, including general knowledge, knowledge of symptoms, and risk factors, by 16 % compared to the control group. This result is comparable to existing controlled studies that showed the efficacy of their interventions in improving stroke-related knowledge (Marto et al., 2017; Williams et al., 2018; Morgenstern et al., 2007). Our intervention also improved self-efficacy for recognizing stroke symptoms by 10 % compared to the control group. To our knowledge, only one existing study included the self-efficacy domain in the intervention and assessment (Williams et al., 2018). This underutilization of the above domain goes against the fact that self-efficacy is the predominant antecedent for health behavior change (Sheeran et al., 2016). Therefore, our intervention improved this essential determinant of EMS activation in secondary school children.

The HOBIT intervention improved stroke behavioral intentions, measuring using realistic video vignettes, by 8 % in the intervention group compared to the control group. To our knowledge, no school-based stroke studies have used video vignettes to evaluate their efficacy in improving behavioral intentions. Given that stroke recognition and responses require aural and visual processing, video vignettes might be a tool with better external validity for measuring the efficacy of stroke preparedness interventions. A similar video tool was developed within the PRAISE study to measure improvements in acute stroke preparedness (Skolarus et al., 2015). Therefore, measuring behavioral intentions using realistic video vignettes could be a promising way to measure help-seeking behavior in acute diseases such as stroke.

The students in the control group improved their stroke knowledge by 8 %. One possible explanation for the improvement in the control group could be the Hawthorne effect, meaning that students the control group could improve their performance in response to being the focus of attention (McCambridge et al., 2014). In other words, students in the control group may know that a follow-up test would follow and prepare the correct answers. Consequently, testing itself can, to some extent, improve stroke knowledge.

Students' baseline knowledge varied by approximately 60 %–70 % for many test items. However, some items had much lower baseline scores. This was the case with the FAST method, which is an effective way for lay people to remember and respond to stroke symptoms (Kleindorfer et al., 2007). The baseline score was deficient for students in both groups (16 % and 25 % in the intervention and control groups). The knowledge of the FAST method improved by 53 % in the intervention group compared to the control group. Our results thus demonstrate that the HOBIT intervention is a highly effective way to educate children about FAST. Such results are very important given that FAST is probably the most important screening tool for stroke used by the public.

Another important finding was that only 47–55 % of the students considered the absence of physical activity, smoking, and salty, fat food as risk factors for stroke at baseline. These findings might have important implications for preventing cardiovascular diseases. If people are unaware of modified stroke risk factors (Feigin et al., 2022), they miss the opportunity to prevent stroke and other cardiovascular diseases. Our study thus underscores the need to improve the education and knowledge of vascular risk factors among children.

Last but not least, the study underlined the effective use of the online approach in school-based health education. Most existing school interventions require the involvement of external experts (Di Carlo et al., 2023; Marto et al., 2017), who do not allow long-term maintenance of the intervention after the end of project funding. The HOBIT program was devised to align with the school curriculum, and its e-learning format enhanced its potential for integration and sustainability within educational institutions. The study also complemented several existing studies with autonomous students' education using manga comics (Ohyama et al., 2015) or online video modules (Tekyol et al., 2023) and showed efficacy similar to existing face-to-face interventions (Tekyol et al., 2023; Ohyama et al., 2015).

4.1. Limitations

Our study has several limitations. First, differential attrition occurred at the school level after randomization. Initially planned for a 2:1 allocation ratio (intervention: control), it shifted to a 3:1 ratio due to attrition. This imbalance weakens the assumption that control and intervention schools were comparable in measured and unmeasured characteristics. It is plausible that attrition was not random, potentially affecting schools whose pupils hadlower motivation in the control group. This could lead to an underestimation of the actual intervention effect. Therefore, the dropout does not compromise the validity of results because our effect estimate is either correct or underestimated.

Second, of all students registered to the e-learning portal, only 65 % in the intervention group and 70 % in the control group were eligible for the analysis. One-third of the students were not eligible for analysis because of the absence of students in the school during the intervention or assessment days and technical problems caused by the intervention's online format. Some students could not complete e-learning due to problems with Internet connections, forgotten nicknames and passwords, or a lack of necessary equipment (e.g., headphones). These technical problems, however, do not diminish the value of the e-learning approach for stroke education since technical problems can be reduced by gradually collecting users' feedback and improving the technical characteristics of the online platform. It is also possible that students' dropout was not random since absence from school may be more likely to affect students with low academic motivation. However, dropouts do not compromise the validity of the results because our effect estimate is either correct or underestimated.

Another limitation of this study is the imbalance in grade composition between the intervention and control groups, with a higher proportion of ninth graders in the intervention group (30 % vs. 10 %). This discrepancy may have influenced the results, as older students might possess greater baseline knowledge and cognitive maturity, potentially facilitating a more effective reception of the educational intervention. However, our baseline analysis revealed no significant differences in knowledge and self-efficacy levels between the groups, suggesting that this factor had a limited impact on the overall intervention effect. Since cognitive development and attention span vary across age groups, younger participants may have required different instructional strategies or additional reinforcement for optimal knowledge retention and behavioral change.

Last but not least, the limitation is the relatively short follow-up period of 5 weeks. While our findings indicate a significant improvement in knowledge, self-efficacy, and behavioral intentions, it remains unclear whether these effects persist over a more extended period. Prior studies suggest that educational gains in similar interventions may diminish over time without reinforcement (Bailey et al., 2020). Therefore, future research should incorporate longer follow-up periods to assess the durability of the intervention effects and explore strategies for reinforcing knowledge retention and behavior change over time.

5. Conclusions

HOBIT, a school-based intervention, improved knowledge, self-efficacy, and behavior intentions regarding EMS activation for suspected stroke in secondary school children. The study employed innovative video vignettes to assess the intervention's effect on behavioral intentions. Notably, the e-learning format makes the HOBIT readily implementable within school curriculums, promoting long-term sustainability without ongoing external support or funding. The results of this study could inform the development of theory and evidence-based school interventions aimed at improving help-seeking behavior, particularly for acute diseases such as stroke.

CRediT authorship contribution statement

Ekaterina Volevach: Writing – original draft, Methodology, Data curation, Formal analysis, Investigation, Validation, Visualization. **Hana Maršálková:** Resources, Project administration, Conceptualization, Funding acquisition, Investigation, Writing – original draft. **Robert Mikulik:** Writing – review & editing, Supervision, Methodology, Conceptualization, Data curation, Formal analysis, Validation.

Informed consent statement

Informed consent was not sought because the study and dataset were completely anonymous and untraceable. Sex, age, and school name were the only personal information requested. Informed consent was not sought from the parents or legal guardians because, after considering the facts above (accreditation and anonymity), it was decided that informed consent was unnecessary and would even carry potential student risks. Practically informed consent withdrawal would mean that children would have to be excluded from the class, which could entail educational, social, and psychological risks associated with exclusion from the educational process.

Institutional review board statement

The study was conducted in accordance with the Declaration of Helsinki. Ethical approval for this study was waived by ethic committee of International Clinical Research Centre, St. Anne's University Hospital Brno because study was reviewed as not a human medical research subject and was deemed exempt according to Act No. 378/2007 Coll., which the State Institute for Drug Control (SUKL) implemented and stipulated the need for ethical approval only for clinical trials.

Funding

No funding was received for the research, authorship, and publication of this article.

Declaration of competing interest

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.

Acknowledgments

The authors are grateful to the participants for their involvement in the project. The authors also thank the team at the Stroke Department of the International Clinical Research Centre, St. Anne's University Hospital Brno, for supporting all team members in the project. The authors are grateful to the Saste Roma project (ZD-ZDOVA2-002), which supported the development and evaluation of the HOBIT program.

Appendix A. Supplementary Data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.pmedr.2025.103049.

Data availability

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

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