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Evaluating an Innovative Technology-based Intervention in Reducing Predictive Stroke Risk and Raising Awareness among Stroke-Free Hypertensive Patients

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Abstract: Background: Early stroke risk reduction in hypertensive patients is crucial, with artificial intelligence (AI) providing accurate risk identification. Leveraging digital technology for risk mitigation is more efficient and less effort-intensive. .**Purpose:** To evaluate an innovative technology-based intervention in reducing predictive stroke risk and raising awareness among stroke-free hypertensive patients. **Setting:** The current study was conducted in medical inpatient and outpatient units at Minia University Hospital, Egypt. **Sampling:** 1:1 randomized controlled trial using a simple random sample of 204 stroke-free hypertensive patients and equally divided into control (one-time educational session) and study group (an innovative technology-based intervention), with balanced baseline characteristics and non-modifiable stroke risk factors. **Instruments:** Two instruments were used; "AI-Based Stroke Risk Calculator Questionnaire" and "Stroke Risk Factor and Warning Signs Awareness Questionnaire," were employed for data collection through structured personal interviews. **Results:** All patients completed the 3-month follow-up. The study group showed a significant reduction in modifiable stroke risk factors. The mean relative reduction in stroke risk score was 44.86% (±4.14) in the study group, compared to 17.56% (±3.95) in the control group (P<0.0001). Stroke risk factor and warning signs awareness improved notably, with the study group achieving a 100.39% (±6.92) relative increase, surpassing the control group's 61.12% (±7.66) (P<0.0001). **Conclusions:** The innovative technology based intervention is effectively reduced modifiable stroke risk factors and AI-calculated stroke probability and enhanced the awareness among stroke-free hypertensive patients. **Recommendations:** Healthcare providers should prioritize addressing both risk factor management and stroke risk awareness by utilizing such a technology-based intervention.

Keywords*: Awareness, Hypertension, Innovative Technology, Stroke risk*

Introduction

Stroke is a significant global health problem, causing substantial morbidity and mortality across diverse populations (American Heart Association, 2021). Africa bears a considerable burden of this problem, with often unfavourable outcomes (Tsao et al., 2022). The challenges posed by stroke in Africa are compounded by a shortage of adequate healthcare facilities, emphasizing the critical importance of decreasing its incidence (Yang, et al., 2023).

Hypertension, or high blood pressure, is consistently recognized as a primary risk factor for stroke (Feigin, et al., 2022a). This risk factor is especially pertinent for hypertensive individuals who have not yet experienced a stroke, as prevention remains the most effective strategy for reducing the impact of this debilitating condition. One of the critical strategies in stroke prevention is identifying the risk level and, the contributing factors and providing effective interventions to reduce their stroke risk (Wajngarten & Silva, 2019).

The development of stroke risk prediction models has been a vital component of preventive care. Recently, artificial intelligence (AI) has been integrated into healthcare solutions to provide better accuracy of risk identification and better recommendations for risk reduction. The stroke riskometer is an example of such a solution that employs artificial intelligence to evaluate an individual’s risk of stroke based on various clinical parameters and demographic data, providing a personalized risk assessment that is both user-friendly and clinically relevant. This innovative approach leverages technology to optimize the accuracy of risk prediction and enhance the educational process (Lip, et al., 2022).

Importantly, the stroke riskometer application emphasizes the Afrocentric risk factors that are particularly relevant to the African population. These Afrocentric risk factors include comorbidities such as hypertension, dyslipidemia, diabetes mellitus, cardiac disease, and a family history of cardiovascular disease. Additional factors include raised waist-hip ratio, stress, salt consumption habits, low consumption of leafy green vegetables, regular sugar consumption, meat consumption, and physical inactivity (Akpa, et al., 2021).

In this era of evidence-based healthcare, it is paramount to evaluate the effectiveness of preventive strategies, especially in individuals at risk for strokes. Nurse-led interventions play a significant role in risk reduction and promoting patient education. Nurses are well-positioned to identify patients at risk, deliver tailored educational interventions, and monitor progress, making them instrumental in reducing stroke risk among at-risk patients (Lin, et al., 2022).

Traditionally, one-time educational session on stroke prevention remains a standard practice in healthcare settings, and its long-term impact on risk reduction has been variable. However, motivational digital health technologies are advisable as they can prevent up to 50% to 90% of stroke and cardiovascular disease events worldwide (Owolabi, et al., 2022). Hence, a more intensive and motivational educational intervention, complemented by the use of educational videos and self-follow-up material, can lead to superior outcomes in terms of stroke risk probability reduction.

By addressing these specific Afrocentric risk factors and utilizing AI-driven risk assessment, this study seeks to contribute valuable insights into optimizing stroke prevention strategies for hypertensive patients. The comparison between traditional health education and the motivational educational collective technology-based intervention will provide a basis for evaluating the potential benefits of personalized, technology-enhanced interventions in reducing stroke risk and improving patient awareness.

Significance of the study:

The prevalence and incidence of stroke in Egypt, particularly among hypertensive individuals (approximately 240 cases per 100,000 population, with a staggering 250,000 new stroke patients each year), paint a concerning picture of the unwavering need for effective intervention strategies (Aref, et al., 2021). Meanwhile, in Fayoum governorate, a community-based study reported a stroke prevalence of 1.6% in the general population and a 7.1% incidence of stroke among hypertensive patients (Shaheen, et al., 2019).

As for stroke awareness and response, a study on stroke awareness among Gharbia governorate residents indicated a need for improved awareness and response to suspected stroke cases. The study underscores the urgency of public education and health campaigns to enhance knowledge of stroke symptoms, encourage swift response, and promote adherence to preventive strategies (Elhassanien, et al., 2023).

Hence, by delving into stroke etiology alongside the potential for innovative interventions the researchers intend to leverage currently available, cost-free, and time-efficient tools. This includes employing artificial intelligence methods to measure predictive stroke risk with higher accuracy, as well as to mitigate this risk among hypertensive patients without a history of stroke.

The current study is expected to make a meaningful impact on the health of patients having hypertension in

Egypt. It serves as a crucial step towards enhancing the overall health and well-being of a great proportion of the Egyptian population and may provide valuable insights for other regions facing similar challenges.

Study Purpose:

The purpose of the study is to evaluate the effectiveness of an innovative technology-based intervention in reducing predictive stroke risk and raising awareness among stroke-free hypertensive patients.

Research hypotheses:

- **H1:** The relative reduction in stroke risk score is expected to be lower in the study group compared to the control group among stroke-free hypertensive patients.
- **H2:** The relative increase in awareness scores of stroke risk factors and stroke warning signs is expected to be higher in the study group compared to the control group following the innovative preventive intervention among stroke-free hypertensive patients.

Method:

Research design:

The current study used a quasi-experimental design (pre-posttest design).

Setting:

The current study was conducted in medical inpatient and outpatient units at Minia University Hospital, Egypt.

Sample:

A parallel-group randomized controlled trial was conducted using a simple random sample with a 1:1 allocation ratio among stroke-free hypertensive patients. The study recruited a total of 204 participants, with 102 in each group (control and study). Eligible patients were randomly assigned into either the control group (received a one-time educational session) or the study group (participants underwent innovative technology-based intervention sessions). These sessions involved digital, individualized, goal-oriented educational interventions.

Inclusion Criteria:

(**1**) Patients should be hypertensive and possess a smartphone; (**2**) aged ≥18 years; (**3**) without a history of stroke or transient ischemic attack; (**4**) able to communicate and participate. However, the researchers exclude hypertensive patients who have severe co-morbidities like chronic end-stage renal diseases, chronic lung diseases, transient ischemic attack and stroke, and pregnant females.

Sample size calculation:

Based on a study by Shaheen et al. (2019), the incidence of new stroke cases among hypertensive patients in Fayoum governorate was reported as 7.1%. To determine the necessary sample size based on proportion, OpenEpi program version 3.01 was used, and the calculated number of patients required for the study was 102.

The following equation was used:

[DEFF*Np(1-p)]/ [(d2/Z21-α/2*(N-1) + p*(1-p)]

Where: **DEFF**: Design effect, was typically assumed to be 1 for simple random sampling, **N**: Population size, which is the total number of Egyptian individuals with hypertension (exceeding 1,000,000 in Egypt), **p**: Expected proportion of the outcome in the population (7.1%)., **d**: Margin of error (0.05), Z2_1-α/2: For a 95% confidence level, α is 0.05 and the critical value is 1.96.

Instruments:

<u>Instrument One</u>: AI-Based Stroke Riskometer Calculator Structured Interview Questionnaire (Stroke Riskometer Application):

The stroke riskometer app is an instrument that uses artificial intelligence to calculate the individual risk of stroke in the next five or ten years, based on a set of 20 questions that cover various risk factors either non-modifiable (such as age, sex) or modifiable (such as blood pressure, diabetes, smoking, physical activity, stress). In the current study, the stated non-modifiable risk factors of the stroke riskometer app in addition to marital status and residence (urban/rural) were collected in baseline time only. However, the modifiable risk factors were collected before and after the intervention. The time to fulfill the required responses was 4-6 minutes.

The instrument is endorsed by the World Stroke Organization and other international and national stroke organizations (Feigin et al., 2022b). The app has been updated several times from 2014 till now. The variables of non-modifiable and modifiable risk factors in the current study are from version 2.1.1 for iOS and version 3.1 for Android of the Stroke Riskometer app, which was released in 2019. It is a useful instrument for assessing and preventing stroke, especially in low- and middle-income countries, where stroke is a major public health problem.

The scoring system is based artificial algorithm which is connected with large current data references from more than 100 countries around the world that gives optimized up-to-date prediction (Medvedev, et al., 2021).

<u>Instrument Two</u>: Structured Interview Questionnaire of Stroke Risk Factor and Warning Signs Awareness (SRFA)

This questionnaire was developed by the researchers based on review of the literature, Akpa, etal., (2021), Centers for Disease Control and Prevention (2022), Pickup Family Neurosciences Institute (2022), and Owolabi et al. (2022). The awareness score was calculated out of a 20-item questionnaire as follows: 2 were related to stroke definition, 13 items were associated with stroke occurrence (based on Afrocentric stroke risk factors), and 5 items for stroke warning signs “BE FAST” acronym: Balance (difficulty with balance or coordination), Eyes (vision problems), Face drooping, Arm weakness, or Speech difficulty. Those warning signs were emphasized as empowerment of individuals for earlier response toward stroke emergency. The time to fulfill the responses to the questionnaire was 4-7 minutes.

Scoring system: The total number of correct responses out of 20 was multiplied by 5 to be converted to %. The score ranges from 0 to 100%. The SRFA score was satisfactory at ≥ 60% and unsatisfactory at < 60%.

Validity and reliability of the instruments:

Regarding instrument one (AI-Based Stroke Riskometer Calculator Questionnaire), it was validated by Parmar et al., (2015). Its reliability was assessed by Medvedev, et al., (2021) who reported that the Stroke Riskometer is reliable and consistent in estimating stroke risk across 13 countries with G-coefficients at 0.80 and higher, meaning that the scores assessed by the Stroke Riskometer are generalizable across persons, items and countries.

For content validity, the developed instrument two (Questionnaire of Stroke Risk Factor and Warning Signs Awareness (SRFA) was further revised by 5 experts in the internal medicine (two professors) and medical-surgical nursing field (three professors) to test its comprehensiveness and clarity and the instrument was modified accordingly. Concerning the reliability of the SRFA, it was tested using the reliability coefficient, Cronbach Alpha was 0.89.

Ethical consideration:

This study was approved by the Research Ethics Committee of the Faculty of Nursing, Minia University, Egypt (No: REC2022112). The purpose and importance of the study were clearly explained to each patient. Following that informed oral and written consents were obtained from patients who agreed to be included in the study. The researchers informed each patient that their participation in the study was voluntary and they could withdraw at any time. All data was coded for confidentiality wise.

Pilot study:

A pilot study was conducted on 10% of the total sample (11 study group and 11 control group) to assess the instrument for its clarity and applicability and to discover any difficulties that may be faced during the actual study. The final form of the instrument was modified accordingly, and patients included in the pilot study were not included in the study.

Procedure:

The study procedure encompassed subsequent distinct phases, including preparatory, patient enrollment, baseline assessment, implementation, and outcome evaluation.

In the preparatory phase, the initial steps involved obtaining written approval from the administrative authority of Minia University Hospital. Subsequently, the researchers evaluated the available space, time, and instructional materials for conducting the educational intervention. An essential aspect of this phase was the meticulous preparation of the educational session content and the materials for the innovative technology-based intervention.

For the face-to-face educational session, a 30-minute comprehensive content was designed, covering essential information about stroke. This included topics such as the definition, types, risk factors, warning signs, complications, preventive measures, medication instructions, dietary guidance, weight reduction, exercise, stress management, smoking reduction, and medical checkups. The content development process involved an extensive literature review from reputable sources, including the Centers for Disease Control and Prevention (2022), Pickup Family Neurosciences Institute (2022), Owolabi et al. (2022), Sheffield Teaching Hospitals NHS Foundation Trust (2021), Stroke Survivor Support Group (2019), and Dartmouth-Hitchcock Medical Center (2012). Additionally, the content underwent testing for applicability and content validity by five experts in the field, with necessary modifications made.

The innovative technology-based intervention utilized videos and an educational leaflet. The list of videos contained a general video about stroke and other videos that targeted the modifiable risk factors. Patients or their relatives could access and replay these videos on a mobile phone. The educational leaflet provided a list of the modifiable stroke-risk factors with corresponding a clear cutoff goal for each risk factor reduction. Like the videos, the leaflet was based on extensive literature and reviewed by experts.

The patient enrollment phase followed; the researchers visited Minia University Hospital two days a week from 8 am to 2 pm. The patients were interviewed individually at the outpatient clinic reception or inpatient medical unit to identify patients who met the inclusion criteria of the study sample. The eligible patients were met individually to explain the purpose and procedure of the study before the informed consent. Then, the researcher enrolled patients who agreed to participate and allocated them to either control or study group 1:1 randomly. Figure (1) shows the flowchart that describes the enrollment of the study and control group. The study was conducted over 10 months (May 2022 to February 2023).

The baseline assessment phase involved using study instruments for both groups. To confirm blood glucose control, glycated haemoglobin (HbA1c) was assessed for both groups. Blood samples were collected by the same laboratory team technicians, centrifuged on-site within one hour, and then transferred to the central laboratory of Minia University Hospital. Body Mass Index (BMI) measurements were taken for each participant using its equation [weight (in kilograms)/ height in meters squared] (Huang, et al., 2021), categorizing them as either having a normal BMI (18.5-24.9) or high BMI (≥25), as there were no underweight participants. Additionally, waist-to-hip ratio (WHR) measurements were taken as an indicator of dyslipidemia and central obesity. Waist and hip circumferences were measured using stretchable tape (Seca 201) in centimetres, over light clothing and without any pressure on the body surface. WC was estimated at the midway between the iliac crest and lower rib margin. The normal range of WHR is ≤ 0.90 for men and ≤ 0.85 for women, while the exceeding values were considered high or abnormal (Baioumi, 2019).

During the implementation phase, the control group received a one-time non-individualized educational session lasting 30 minutes (maximumly 15 attendants per session), followed by a discussion. In contrast, the study group participated in a more extended intervention program lasting three months. They were exposed to the general stroke video and videos that targeted the individualized modifiable risk factors. The nurse marked each individual's risk factors and reduction goal cutoff on the educational leaflet. Patients watched the videos for the first time in the hospital and had the opportunity to seek clarification. This individualized approach allowed for targeted interventions based on each patient's specific risk profile.

Furthermore, the study group received monthly follow-ups to ensure continued engagement and motivation throughout the intervention period. Patients received monthly follow-up calls or messages to rewatch the videos and confirm with a reply message, serving as a means of refreshing their understanding of risk reduction goals and providing ongoing support and guidance.

In the study outcome evaluation phase, outcomes were assessed after a 3-month implementation period. The primary outcome included the relative reduction in stroke modifiable risk factors and the total predictive stroke risk score. Secondary outcomes focused on the relative increase in stroke risk factors and warning signs awareness scores over 3 months. Importantly, researchers ensured that control group patients were not exposed to the interventional materials related to the study group.

Relative change as a powerful study outcome

Presenting relative change, rather than absolute change, is a powerful tool for understanding the impact of each interventional technique in both control and study groups. Absolute change is just the difference between pre and post-intervention with quantifying the power of the utilized technique. Relative change percentage presents the power that relative to each technique to change the baseline characteristic. Indeed, it offers a nuanced perspective by calculating the proportional shift from the pre-test to the post-test. For instance, the relative reduction in risk is determined as the percentage change from the pre-test risk to the post-test risk, providing a more comprehensive measure of the effectiveness of each interventional approach. Similarly, the relative increase in awareness was assessed, offering insights into the interventional techniques' ability to positively influence patients' awareness levels, thus offering a more nuanced and informative evaluation of the study's outcomes.

Calculation of relative change (either reduction or increase):

To present the ability of each educational technique to produce a change in risk or awareness from pre-test to post-test, the relative change % was calculated as follows:

- **Relative Risk Reduction % =**

[(Risk in Pre-test) – (Risk in Post-test) / Risk in Pre-test] X 100

- **Relative Awareness Increase % =**

[(Awareness in Pre-test) – (Awareness in Post-test) / Awareness in Pre-test] X 100

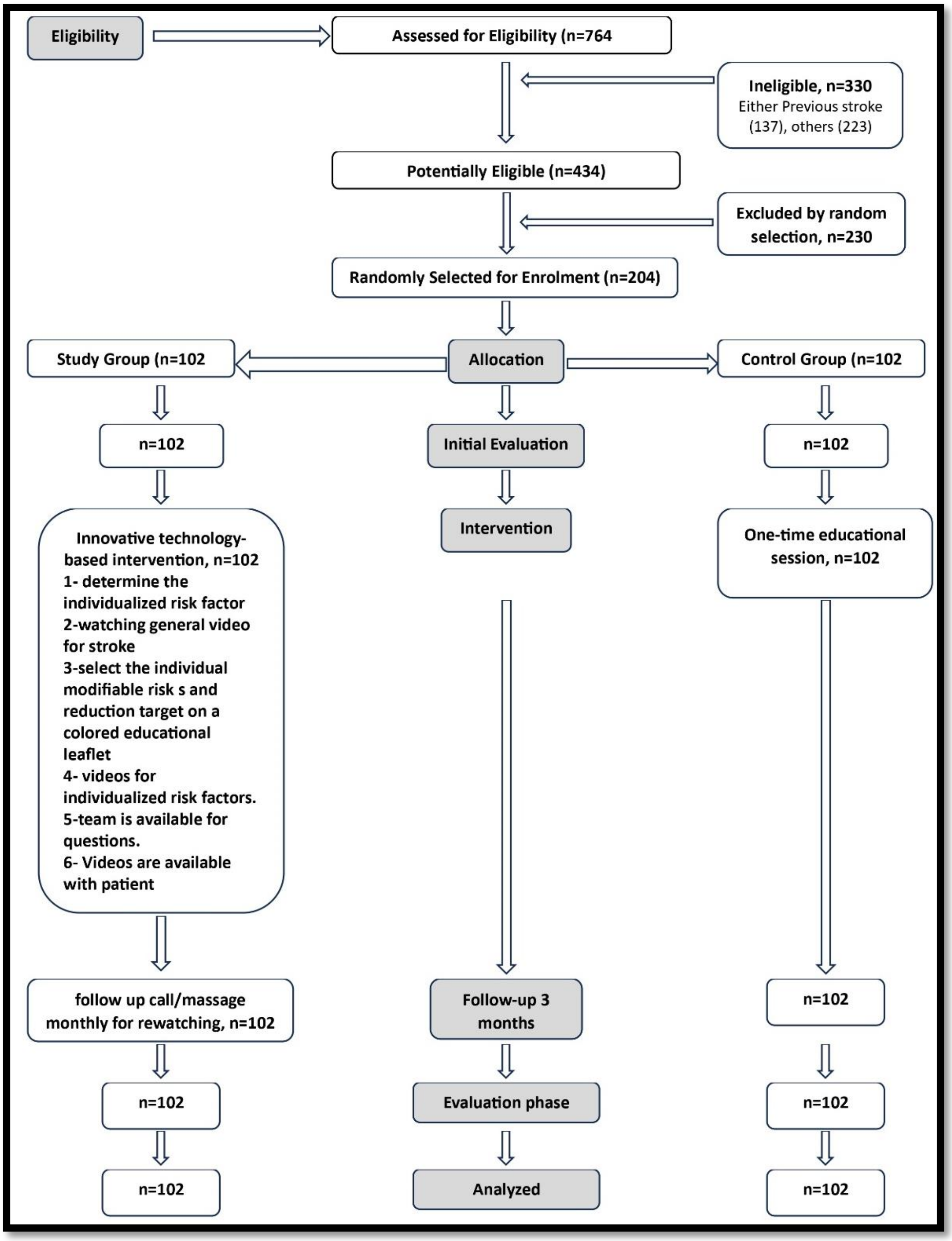

Fig. 1 : Study flowchart

Statistical Analysis:

Data were entered and analyzed using IBM SPSS, version 25. Data were described using percentages and means. Statistical analysis was done using the chi-square test or Fisher exact test (when cell counts < 5) while the independent t-test was used to test the difference between means. A statistically significant difference was considered if $P < 0.05$. A highly statistically significant difference was considered if $P \leq 0.01$.

Results:

Table 1 displays the characteristics of patients in the control and study groups. The findings indicate that the control and study groups are well-matched in terms of setting, age, gender, and marital status, with slight variations in the percentage distribution of other characteristics. Control and study groups aged nearly the same (50.79 ± 13.61, 49.08 ± 13.83, respectively) with the lowest percentage for those aged 70 years and older (7.8%., 5.9%, respectively). Males occupied 50% of the control group and 51% of the study group.

Table 2 summarizes risk factors among patients in the control and study group pre and post-intervention. Notably, both groups saw a decrease in high SBP (≥140), with a significant 61% reduction in the study group compared to 28% in the control group. BMI > 24.9 kg/m² was declined in the two groups, but the study group showed a more notable reduction (29%) versus the control group (1%). Also, high WHR percentages declined in both, with a substantial 23% decrease in the study group compared to 1% in the control group.

Concerning HbA1c, it changed minimally in the control group (6%) but remarkably dropped by 79% in the study group. While physical inactivity was reduced in both groups, with a higher 68% decrease in the study group versus 49% in the control group. Both groups decreased low vegetable/fruit intake, but the study group had a more significant drop (97%) compared to the control group (66%).

Moreover, high meat intake in the study group showed a 79% relative reduction, surpassing the control group's 24% reduction. High salt intake percentages were decreased in the two groups, with a substantial 50% drop in the study group versus 19% in the control group. Concerning stress levels, they were notably reduced in both groups by 87% in the study group and 6% in the control group. Smoking percentages were decreased by 52% in the study group and 5% in the control group. It is observed that there were very highly statistically significant differences between the control and study groups concerning previously mentioned items where p-value <0.0001.

Table 3 shows patients' awareness score of stroke risk factors and stroke warning signs in the control and study groups pre and post-intervention. Notably, study group patients had satisfactory awareness (≥60%) surged from 11.8% to 87.3%, surpassing the control group increase from 9.8% to 50%. The mean awareness score in the study group ranged from 38.92 (±19.35) to 77.99 (±19.13). Whereas the control group showed a more moderate increase from 36.57 (±19.0) to 58.92 (±20.97). Crucially, the study group exhibited a remarkable 100.39% (±6.92) awareness score increase, surpassing the control group which showed a 61.12% (±7.66) increase. The t-test showed a very highly statistically significant difference ($p<0.0001$), emphasizing the intervention's greater effectiveness on the study group. Moreover, it is observed that there were very highly statistically significant differences between the control and study group itself regarding levels of awareness and its mean score where p-value < 0.0001, as well as, between study and control group regarding change in awareness score where p-value < 0.0001.

Table 4 details stroke-probability risk scores between patients in the control and study group pre and post-intervention. Patients in the study group classified as low risk (<5%) surged from 0% to 29.4%, outpacing the control group's increase from 0% to 6.9%. High-risk patients (10-20%) in the study group dropped from 80.39% to 31.4%, on the contrary in the control group's increased from 81.37% to 86.6%. The mean stroke probability scores significantly decreased in the study group from 14.219 (±3.93) to 7.84 (±4.47), with a moderate decrease in the control group from 14.69 (±3.92) to 12.11 (±4.36). Both groups markedly improved post-intervention ($p<0.0001$), signalling a significant reduction in stroke probability scores. Regarding the percentage change, the study group showed a 44.86% (±4.14) decrease, surpassing the control group's 17.56% (±3.95) decrease. The t-test revealed a very highly statistically significant difference ($p<0.0001$), emphasizing the more pronounced reduction in the study group's stroke probability scores post-intervention.

Table 5 illustrates the correlation between patients' awareness of stroke risk score factors and stroke warning signs pre and post-intervention. It exhibits very highly statistically significant negative correlations between stroke probability scores and awareness scores of stroke risk factors and warning signs, in both pre and post-intervention. Pre-intervention, in the control group, awareness correlated strongly at -0.991 ($p < 0.0001$), and in the study group, it was -0.994 ($p < 0.0001$). Post-intervention, the negative correlation persisted significantly, with - 0.990 ($p < 0.0001$) in the control group and - 0.974 ($p < 0.0001$) in the study group.

Table 1. Characteristics of patients in the control and study group (n=204)

Variable	Control Group (n=102)	Study Group (n=102)	X2	p-value
Setting				
▪ Inpatient	52(51%)	51(50%)	0.02	0.889
▪ Outpatient	50(49%)	51(50%)		
Age				
▪ < 40 yrs	**19(18.6%)**	**23(22.5%)**	0.913	0.923
▪ 40-49 yrs	26(25.5%)	28(27.5%)		
▪ 50-59 yrs	27(26.5%)	25(24.5%)		
▪ 60-69 yrs	22(21.6%)	20(19.6%)		
▪ >69 yrs	8(7.8%)	6(5.9%)		
▪ Mean ± SD	50.79 ± 13.61	49.08 ± 13.83		
Gender				
▪ Male	51(50%)	52(51%)	0.02	0.889
▪ Female	51(50%)	50(49%)		
Educational Level				
▪ Illiterate	23(22.5%)	19(18.6%)	1.239	0.872
▪ read and write	24(23.5%)	26(25.5%)		
▪ Elementary	11(10.8%)	8(7.8%)		
▪ Secondary	18(17.6%)	21(20.6%)		
▪ bachelor or higher	26(25.5%)	28(27.5%)		
Income				
▪ not enough	12(11.8%)	11(10.8%)	0.05	0.976
▪ Enough	82(80.4%)	83(81.4%)		
▪ enough and save	8(7.8%)	8(7.8%)		
History of Atrial Fibrillation				
• No	24(23.5%)	28(27.5%)	0.4109	0.5215
• Yes	78(76.5%)	74(72.5%)		
Family History of Stroke				
• No	97(95.1%)	94(92.2%)	0.739	0.39
• Yes	5(4.9%)	8(7.8%)		
Family History of heart attack				
▪ No	94(92.2%)	95(93.1%)	0.072	0.789
▪ Yes	8(7.8%)	7(6.9%)		
Family History of Diabetes Mellitus				
▪ No	53(52%)	43(42.2%)	1.968	0.161
▪ Yes	49(48%)	59(57.8%)		

Residence				
▪ Urban	33(32.4%)	36(35.3%)	0.197	0.657
▪ Rural	69(67.6%)	66(64.7%)		
Marital status				
▪ Single	4(3.9%)	6(5.9%)	0.424	0.935
▪ Married	83(81.4%)	81(79.4%)		
▪ Divorced	1(1%)	1(1%)		
▪ Widowed	14(13.7%)	14(13.7%)		

Table 2: Risk factors among patients in the control and study group pre and post-intervention (n=204)

Risk Factors	Modifiable stroke risk factor				Relative reduction in each risk factor	
	Control Group (n=102)		Study Group (n=102)		Control Group (n=102)	Study Group (n=102)
	Pre n (%)	Post n (%)	Pre n (%)	Post n (%)	%	%
Systolic BP ≥140	65(63.7%)	47(46.1%)	61(59.8%)	24(23.5%)	28%	61%
X2 (P-Value)	6.349 (0.0117) **		27.517 (<0.0001) **		21.937 (<0.001) **	
Body mass index >24.9 kg/m2	79(77.5%)	78(76.5%)	77(75.5%)	55(53.9%)	1%	29%
X2 (P-Value)	0.029 (0.866)		10.367 (0.0013) **		30.591 (<0.001) **	
High Waist to Hip ratio	87(85.3%)	86(84.3%)	83(81.4%)	64(62.7%)	1%	23%
X2 (P-Value)	0.039 (0.843)		8.813 (0.003) **		22.802 (<0.001) **	
HbA1c>5.6 %	68(66.7%)	64(62.7%)	70(68.6%)	15(14.7%)	6%	79%
X2 (P-Value)	0.356 (0.551)		60.668 (<0.0001) **		108.49 (<0.001) **	
Physical inactivity	61(59.8%)	31(30.4%)	65(63.7%)	21(20.6%)	49%	68%
X2 (P-Value)	17.72 (<0.0001) **		38.662 (<0.0001) **		7.398 (0.007) **	
low vegetables/fruits	76(74.5%)	26(25.5%)	78(76.5%)	2(2%)	66%	97%
X2 (P-Value)	48.74 (<0.0001) **		118.131 (<0.0001) **		31.709 (<0.001) **	
High meat intake	50(49%)	38(37.3%)	47(46.1%)	10(9.8%)	24%	79%
X2 (P-Value)	2.83 (0.092)		33.207 (<0.0001) **		60.252 (<0.001) **	
High salt intake	52(51%)	42(41.2%)	58(56.9%)	29(28.4%)	19%	50%
X2 (P-Value)	1.962 (0.161)		16.853 (<0.0001) **		21.157 (<0.001) **	
Stress	70(68.6%)	66(64.7%)	71(69.6%)	9(8.8%)	6%	87%
X2 (P-Value)	0.347 (0.556)		78.714 (<0.0001) **		131.207 (<0.001) **	
Smoking	21(20.6%)	20(19.6%)	21(20.6%)	10(9.8%)	5%	52%
X2 (P-Value)	0.032 (0.859)		4.592 (0.032) *		53.931 (<0.001) **	

**P*-value is significant at < 0.05. ***P*-value is highly significant at ≤ 0.001.

Table (3): Patients' awareness score of stroke risk factors and stroke warning signs in the control and study groups pre and post-intervention (n=204)

Awareness score of stroke risk factors and stroke warning signs	Control Group (n=102)		Study Group (n=102)	
	Pre	Post	Pre	Post
	n (%)	n (%)	n (%)	n (%)
Level of awareness				
▪ Unsatisfactory (<60%)	92 (90.2%)	51 (50%)	90 (88.2%)	13 (12.7%)
▪ Satisfactory (≥60%)	10 (9.8%)	51 (50%)	12 (11.8%)	89 (87.3%)
X2 test (P-value)	39.1199 (<0.0001) **		115.696 (<0.0001) **	
Mean score of awareness				
▪ Mean ± SD	36.57 ± 19.0	58.92±20.97	38.92±19.35	77.99±19.13
▪ Paired t-test (P-Value)	7.977 (<0.0001) **		14.502 (0.0001) **	
Change in awareness score				
▪ Relative increase in Awareness (Mean% ± SD)	61.12 % (±7.66)		100.39 % (±6.92)	
t-test (P-value)	38.042 (<0.0001) **			

***P*-Value is highly significant at ≤ 0.001

Table (4): Stroke-probability risk scores between patients in the control and study group pre and post-intervention (n=204)

Stoke probability risk score	Control Group (n=102)		Study Group (n=102)	
	Pre	Post	Pre	Post
	n (%)	n (%)	n (%)	n (%)
Level of stroke probability				
▪ Low risk (<5%)	0.0 (0.0%)	7 (6.9%)	0.0 (0.0%)	30 (29.4%)
▪ Moderate risk (5%- <10%)	13 (12.75%)	22 (21.7%)	15 (14.7%)	39 (38.2%)
▪ High risk (10%-20%)	83 (81.37%)	70 (68.6%)	82 (80.39%)	32 (31.4%)
▪ Very high risk (>20%)	6 (5.8%)	3 (2.9%)	5 (4.9%)	1 (0.98%)
X^2 test (P-value)	11.419 (0.0097) **		65.263 (<0.0001) **	
Mean score of stroke probability				
▪ Mean ± SD	14.69 ± 3.92	12.11±4.36	14.219± 3.93	7.84±4.47
▪ Paired t-test (P-Value)	4.444 (<0.0001) **		10.824 (<0.0001) **	
Change in stroke risk				
▪ % Relative reduction change in stroke risk score, Mean% (± SD)	17.56% (±3.95)		44.86% (±4.14)	
t-test (P-value)	47.710 (<0.0001) **			

***P*-Value is highly significant at ≤ 0.0001

Table (5): Correlation between patients' awareness of stroke risk score factors and stroke warning signs pre and post-intervention

Correlation	**Stroke risk Score**			
	Pre-intervention		**Post-intervention**	
	Control group	**Study group**	**Control group**	**Study group**
	r (P-Value)	**r (P-Value)**	**r (P-Value)**	**r (P-Value)**
Awareness of stroke risk factors and stroke warning signs	- 0.991**(<0.0001)	- 0.994** (<0.0001)	- 0.990** (<0.0001)	- 0.974** (<0.0001))

***P*-Value is highly significant at ≤ 0.001

Discussion:

To the best of study researchers' knowledge, there are limited studies in providing such well-structured motivational goal-oriented collaborative technology-based intervention in raising awareness of stroke risk factors and stroke warning signs among hypertensive stroke-free patients and the utilization of the artificial intelligence tool in the evaluation of its effectiveness. This comes in line with the current global trend of AI instruments and early risk identification and earlier risk reduction.

The present study findings revealed that there are no statistically significant differences in age, gender, education, residence, marital status, income, history of atrial fibrillation or family history of stroke, heart attack and diabetes between the two groups. This balance supports the comparison of modifiable risk factors and the assessment of the intervention's impact on stroke risk. importantly. The results are also similar to the demographic and epidemiological data of the Egyptian population, which has a high prevalence of hypertension and stroke, and a low level of awareness and control of these conditions (Aref, et al., 2021; Elhassanien, et al., 2023). From the researchers' point of view this occurred due to the current non-blind randomized control research started with indicate that the two groups are well-balanced and comparable results between the study and control group in baseline characteristics and non-modifiable stroke risk factors.

The current findings found that there were highly significant statistical differences between the control and study groups concerning the relative reduction in modifiable stroke risk factors pre and post-intervention. The results are consistent with the hypothesis that the motivational innovative preventive intervention will significantly reduce the AI-calculated stroke occurrence probability among stroke-free hypertensive patients in Egypt. The results are also in line with the evidence from previous studies that have shown the effectiveness of motivational interviewing and individualized education in improving blood pressure control, medication adherence, lifestyle modification, and stroke knowledge among stroke survivors and high-risk populations (Brouwer-Goossensen et al., 2022; Papus et al., 2022). From the researchers' point of view, the changes in each modifiable stroke risk factor between control and study groups pre and post-intervention, indicate that the intervention had a significant positive impact on reducing the stroke risk factors in the study group, compared to the control group that received usual care.

The most remarkable finding of the study is the substantial reduction in the percentage of individuals with high systolic blood pressure (≥140 mm Hg) in the study group, from 59.8% at pre-intervention to 23.5% at post-intervention as a follow-up, compared to a modest reduction in the control group, from 63.7% to 46.1%. From the researchers' point of view, this finding suggests that the intervention was successful in enhancing the patients' awareness, motivation, and self-efficacy to adhere to their antihypertensive medications and to monitor their blood pressure regularly.

High blood pressure is indeed the most important modifiable risk factor for stroke, a study of 123 randomized controlled trials by Gorelick, et al., (2019) found that a reduction of systolic blood pressure by 10 mm Hg reduced the risk of stroke by 35-40%. Moreover, another meta-analysis published in 2023 suggested that more intensive blood pressure-lowering therapy might be associated with a reduced risk of recurrent stroke and major cardiovascular events (Hsu et al., 2023). Therefore, the intervention has the potential to prevent a large number of stroke events and save lives in Egypt, where hypertension is highly prevalent and poorly controlled and it affects around thirty million adult Egyptians, according to the last national registry (Khalfallah, et al., 2023).

Another notable finding of the study is the significant improvement in the glycemic control of the study group, as indicated by the remarkable reduction in the percentage of individuals with high haemoglobin A1c (≥6.5%) from 68.6% at pre-intervention to 14.7% at post-intervention as a follow-up, compared to a minimal reduction in the control group from 66.7% to 62.7%. From the researchers' point of view, this finding implies that the intervention was effective in increasing the patients' knowledge, motivation, and self-efficacy to adhere to their antidiabetic medications and to follow a healthy diet and physical activity regimen.

In Egypt, diabetes mellitus is believed to be a major risk factor for stroke with high prevalence and poor control. The prevalence of diabetes mellitus in Egypt reached 20.9% in 2021(Knoema, 2023), and projections indicate a further increase to 12.6% by 2045. This surpasses the global prevalence of diabetes mellitus, which stood at 10.5% in 2021, with an anticipated rise to 11.9% by 2045, as reported by the International Diabetes Federation (2021). Importantly, lowering haemoglobin A1c by 1% might reduce the risk of stroke by 17% (Mitsios, et., 2018), while an A 1-unit increase in A1c among individuals with diabetes increases the risk of macrovascular disease (MI, stroke, or PAD) by 18%, and attaining glycemic control can reduce the risk of stroke (Joseph et al., 2022). Hence, the study group intervention would have a significant impact on reducing the stroke burden in Egypt.

The current study also found significant improvements in other modifiable stroke risk factors in the study group, such as waist-to-hip ratio, physical inactivity, low vegetable/fruit intake, high meat intake, high salt intake, stress level, and smoking status. These findings are consistent with Hankey, (2020) who reported that the intervention was successful in influencing the patients' attitudes, subjective norms, and perceived behavioural control to adopt and maintain healthy behaviours that can reduce their stroke risk, such as weight management, physical activity, dietary modification, smoking cessation, and stress management. These behaviours are interrelated and can have synergistic effects on lowering the stroke risk. Therefore, the intervention can have a comprehensive and holistic impact on improving the health and well-being of the patients.

Regarding the comparison of AI-calculated stroke probability scores between the control and study group pre and post-intervention, the current results indicate that the intervention had a significant positive impact on reducing the stroke probability scores in the study group, compared to the control group. The most remarkable finding of the study is the substantial increase in the percentage of the patients classified as low risk (<5%) in the study group, from 0% to 29.4%, compared to a moderate increase in the control group, from 0% to 6.9%. Additionally, there is a significant decrease in the percentage of the patients classified as high risk (10-20%) in the study group, from 80.39% to 31.4%, compared to a slight increase in the control group, from 81.37% to 86.6%. This finding is important, as high-risk individuals have a 10-20% chance of having a stroke in the next five or ten years, which is a very high probability that requires urgent intervention and management. Hence, the intervention was successful in lowering the stroke risk of the participants to a safe level, as indicated by the AI-calculated stroke probability instrument.

More evident, the percentage of change in stroke AI-calculated probability score shows a 44.86% (±4.14) decrease in the study group compared to a 17.56% (±3.95) decrease in the control group. This finding demonstrates the greater effectiveness of the intervention on the study group. Moreover, the percentage of change in stroke probability scores is a measure of the relative improvement or deterioration of the stroke risk over time, based on the AI-calculated stroke probability instrument. The higher the percentage of change, the greater the improvement or deterioration of the stroke risk. The percentage of change can help patients to monitor their progress and to evaluate the impact of their interventions on their stroke risk.

However, these results cannot be compared numerically with previous studies as it represents a new act, conceptually they are in line with the trend findings of other studies that had adopted untraditional educational interventions (Brouwer-Goossensen, et al., 2022; Ihl, et al., 2022; Papus, et al., 2022).

Notably, the study also found a highly statistically significant strong correlation with an r value exceeding 0.9 out of 1 in the negative direction between stroke probability scores and awareness scores of stroke risk factors and warning signs either pre or post-intervention in both groups, From the researchers' point of view, this signifying that as patients' awareness improved, their stroke probability scores continued to decrease. In addition, the novel way that was conducted in the study group presented a great increase in the awareness score; greater stroke risk would be reduced.

Finally, conceptually, correlation achieved a great value as the stroke risk factors and warning signs questionnaire was formulated based on the stated factors in the stroke riskometer app. The intervention in the study group provided great success in enhancing the patients' awareness of the major stroke risk factors and warning signs, and this awareness was associated with lower stroke risk, as indicated by the AI-calculated stroke probability instrument. Therefore, the intervention has the potential to prevent a large number of stroke events and reduce stroke-related mortality and disability in Egypt, where stroke is a major public health problem and the awareness of stroke risk factors and warning signs is low.

Conclusions:

The results of this study demonstrate that the innovative preventive intervention was effective in reducing AI-calculated stroke risk and raising awareness among stroke-free hypertensive patients. The study group exhibited more substantial improvements in modifiable risk factors, awareness, and stroke probability scores, signifying the intervention's superior impact. These findings highlight the potential of innovative technology-based intervention in stroke prevention, emphasizing the significance of increased awareness in achieving better health outcomes.

Limitations of the study:

The study has some limitations that should be acknowledged. First, the follow-up period was relatively short, which may limit the generalizability and the long-term effects of the intervention. Second, the study relied on self-reported measures of some stroke risk factors, such as physical activity, dietary intake, stress level, and smoking status, which may be subject to recall bias and social desirability bias. Future studies should address these limitations by using larger and more diverse samples, longer follow-up periods, and objective measures of stroke risk factors.

Recommendation:

The study underscores key recommendations for effective stroke risk reduction among stroke-free hypertensive patients. Utilizing freely accessed technology tools can enhance early stroke risk identification and awareness, facilitating tailored educational interventions. Interdisciplinary care and public health campaigns targeting at-risk populations are crucial. Integrating stress reduction, smoking cessation, and dietary changes can positively impact stroke risk. Long-term follow-up studies are vital for assessing sustainability. Recommending regular screening and monitoring, particularly with high-accuracy, freely accessed AI methods, enhances comprehensive stroke prevention efforts. Implementing these recommendations in clinical practice and public health initiatives can significantly reduce the burden of stroke in hypertensive populations.

Declaration of competing interests:

None

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