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A Nurse-Led, Age-Friendly Educational Program to Reduce Stroke Risk and Promote Healthy Behaviors among Older Adults: A Randomized Controlled Trial

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Abstract

Background: Stroke remains a major cause of disability and mortality globally, particularly among older adults in low- and middle-income countries. Integrating the 4Ms framework (What Matters, Medication, Mentation, and Mobility) into nursing-led preventive interventions offers a holistic, person-centered model for promoting healthy aging and mitigating stroke risk.

Aim: This study evaluated the effectiveness of a nurse-led, age-friendly educational program, grounded in the 4Ms framework, in reducing stroke risk and enhancing health-promoting behaviors among older adults.

Methods: A randomized controlled trial was conducted with 170 community-dwelling adults (≥60 years) attending outpatient clinics in Egypt. Participants were randomized to either a 4Ms-based educational intervention (two structured sessions and materials) or a control group receiving routine care. Outcomes were measured using the Revised Framingham Stroke Risk Profile, the Health-Promoting Lifestyle Profile II, and a stroke prevention practices questionnaire.

Results: Post-intervention, the intervention group demonstrated a significant reduction in 10-year stroke risk scores ($p<.001$) and significant improvements across all health-promoting behavior domains, especially physical activity, nutrition, and stress management (all $p<.001$). The percentage of participants with good stroke-prevention practices increased from 7.1% to 55.3%. Stroke risk was also inversely correlated with domains like health responsibility and stress management.

Conclusions: The nurse-led, 4Ms-based educational program is highly effective in reducing stroke risk and fostering healthy behaviors among older adults in a low-resource setting. Embedding the 4Ms framework within preventive nursing care provides a sustainable and holistic approach to healthy aging.

Introduction

Stroke remains one of the most significant public health challenges worldwide and a leading cause of long-term disability among older adults. The burden of stroke is particularly high in low- and middle-income countries (LMICs), where demographic transitions, unhealthy lifestyle patterns, and limited access to preventive health services contribute to escalating incidence rates (Feigin et al., 2023; Owolabi et al., 2021). As populations age, the need for effective, sustainable, and person-centered strategies to mitigate stroke risk among older adults becomes increasingly urgent.

Advancing age is inherently linked with vascular changes, multi-morbidity, and reduced functional capacity, all of which heighten vulnerability to stroke and other non-communicable diseases. Despite advances in acute care and rehabilitation, primary prevention remains the most cost-effective and sustainable approach to reducing the global stroke burden (Benjamin et al., 2019). Behavioral risk factors such as physical inactivity, poor diet, smoking, and stress are major contributors to stroke risk, yet they are modifiable through targeted, nurse-led educational interventions (Govori et al., 2024; Kim et

al., 2023). Nurses, as trusted and accessible healthcare providers, play a pivotal role in delivering such interventions and empowering older adults to adopt healthy lifestyles that promote longevity and quality of life.

The Age-Friendly Health Systems (AFHS) movement, initiated by the Institute for Healthcare Improvement, offers a structured framework for delivering person-centered care that aligns with the priorities of older people. Central to this framework are the **"4Ms"**: *What Matters, Medication, Mentation,* and *Mobility*. These interconnected domains ensure that care for older adults is comprehensive and responsive to their individual values, goals, and functional needs (Fulmer et al., 2018; Mate et al., 2021). When integrated into preventive health education, the 4Ms framework facilitates a holistic approach to ageing well by enhancing cognitive, physical, and emotional health while promoting medication safety and adherence (Lesser et al., 2022).

While the 4Ms framework has been successfully implemented in acute and long-term care settings, its application in community-based stroke prevention programs remains limited, particularly in LMICs. Existing initiatives in Egypt and similar contexts often emphasize medical management rather than health promotion, leaving gaps in behavioral and lifestyle modification support for older adults (Shehata et al., 2022). This highlights a pressing need for evidence-based, culturally appropriate, nurse-led programs that operationalize the 4Ms framework to promote stroke prevention and healthy ageing within community and outpatient contexts.

Grounded in gerontological nursing theory and practice, this study integrates the 4Ms framework into an educational intervention designed to empower older adults to actively manage their health risks. The approach reflects commitment to advancing nursing practice that supports independence, autonomy, and functional wellbeing in older people.

Therefore, this study aimed to evaluate the effectiveness of a nurse-led, age-friendly educational program based on the 4Ms framework in reducing stroke risk and enhancing health-promoting behaviors among older adults in Egypt. By integrating established stroke prevention strategies with person-centered, age-friendly principles, this research seeks to advance gerontological nursing practice and contribute to global efforts toward promoting healthy ageing in low-resource environments.

Methods

Study Design

A randomized controlled trial (RCT) was conducted to evaluate the effectiveness of a nurse-led, age-friendly educational program designed to reduce stroke risk and promote healthy behaviors among older adults. This design was selected to reduce selection bias and provide a robust comparison between the structured nurse-led intervention and routine care. Despite the relatively brief intervention period, the RCT affords stronger internal validity compared with uncontrolled pre-test/post-test designs and better supports causal inference about the effect of the intervention on short-term behavioral outcomes. The

intervention was grounded in the Age-Friendly Health Systems “4Ms” framework What Matters, Medication, Mentation, and Mobility which guided the delivery of person-centered, holistic nursing care throughout the trial.

Setting and Participants

The study was conducted within the outpatient hypertension, cardiology, and diabetes clinics of X University Hospital, Egypt. To recruit the sample, systematic random sampling was used to identify 170 eligible older adults, aged ≥60 years, who were then randomly assigned to either the intervention group (n=85) or the control group (n=85).

Participants had to meet four specific inclusion criteria: (1) be 60 years of age or older; (2) have a confirmed diagnosis of hypertension, diabetes, or cardiac disease; (3) be cognitively capable of participating in educational sessions, as verified through a clinical interview; and (4) provide informed consent. Conversely, participants were excluded if they had an active psychiatric illness, significant sensory impairments, or a recent history of stroke, ensuring both participant safety and data consistency.

Intervention Framework

Usual care: Patients in the control arm received routine outpatient care provided at the participating clinics. This typically comprised clinician-led advice during medical appointments, intermittent counselling on chronic disease management, and the occasional distribution of generic informational leaflets. No structured, nurse-led educational sessions, goal-setting, or scheduled follow-up calls were provided to the control group.

Adaptation for limited literacy: Educational materials and delivery were tailored for participants with low literacy. All educational content was presented orally by trained nurse facilitators using large-font pictorial booklets, pictograms, and simple Arabic phrasing. Group demonstrations, role-play, teach-back methods, and caregiver involvement were used to ensure comprehension. Materials emphasized stepwise actions (e.g. how to perform a home blood pressure check) and included contact cards to support adherence.

Individualized feedback: Immediately after baseline assessment, each participant received a brief individualized action plan developed collaboratively with the nurse facilitator, linking 'What Matters' (personal goals) to concrete, achievable steps (e.g. walking 15 minutes daily, simplifying medication schedules). Nurses provided tailored medication adherence advice and demonstrated mobility and breathing exercises appropriate to participants' functional abilities. Participants received brief follow-up calls at 2 and 8 weeks post-intervention to reinforce goals and troubleshoot barriers.

Timing of assessments and follow-up: The intervention consisted of two weekly, 90-minute educational sessions delivered during weeks 1 and 2. Sessions were conducted in small groups (8–10 participants), utilizing interactive discussions, PowerPoint presentations, demonstrations, and illustrated Arabic-language booklets. Following the sessions, participants were also encouraged to perform self-directed breathing and relaxation exercises three times per week for the duration of the 16-week follow-up period.

Outcome assessments were conducted at two time points: baseline (pre-intervention) and 16 weeks (4 months) post-intervention. Statistical analysis compared the baseline and 16-week scores using the within- and between-group tests detailed in the Data Analysis section.

Sample size and power: Sample size was calculated a priori to detect a moderate effect (Cohen's d = 0.50) on primary outcomes (domain scores of the HPLP-II) with a two-sided α = 0.05 and 80% power, which required 64 participants per group. Allowing for up to 25% attrition, a target of 85 participants per group (total n = 170) was set. The trial experienced minimal attrition: all randomized participants completed the 16-week follow-up assessments (n retained = 85 per group).
The educational program was explicitly structured according to the 4Ms framework of age-friendly care (Mate et al., 2021). Each component was operationalized as follows:

What Matters: The nurse facilitator began each session by eliciting participants' values, goals, and personal health priorities related to stroke prevention and healthy aging. These guided individualized action plans.

Medication: Participants received education on medication adherence, the importance of following prescribed antihypertensive and antidiabetic regimens, and safe medication management, using simplified guides tailored for older adults.

Mentation: Cognitive engagement and emotional well-being were promoted through activities such as memory exercises, breathing techniques, and stress-reduction strategies.

Mobility: Instruction emphasized safe physical activity, balance, and fall-prevention exercises to enhance cardiovascular health and reduce stroke risk.

Data Collection Instruments

Four validated instruments were used for data collection:

Sociodemographic and Clinical Data Form:
Gathered information on participants' demographics, medical diagnoses, and major stroke risk factors (e.g., smoking, blood pressure, comorbidities).

Revised Framingham Stroke Risk Profile (R-FSRP):
Estimated 10-year stroke risk using age, systolic blood pressure, diabetes status, smoking, cardiovascular disease, atrial fibrillation, and ECG results (Dufouil et al., 2017).

Health-Promoting Lifestyle Profile II (HPLP-II):

The (HPLP-II) is a 52-item instrument assessing six distinct behavioral domains nutrition, physical activity, health responsibility, spiritual growth, interpersonal relations, and stress management each rated on a four-point Likert scale (Walker et al., 1987). Each HPLP-II domain captures a specific health behavior relevant to stroke prevention: Nutrition evaluates dietary choices that directly influence blood

pressure and lipid control (e.g., fruit/vegetable intake, salt/fat moderation); Physical Activity captures the frequency and intensity of movement relevant to cardiovascular fitness; Health Responsibility measures proactive behaviors such as self-monitoring and medication adherence; Spiritual Growth reflects meaning-making and coping that support resilience; Interpersonal Relations assesses social support and connectedness known to affect adherence; and Stress Management evaluates coping and relaxation practices that modulate physiologic stress responses. We analyzed domain-specific scores to determine which behavioral components were modified by the intervention and how these changes correlated with stroke risk reduction.

Stroke Prevention Practices Questionnaire:
A researcher-developed tool evaluating knowledge and behaviors related to stroke prevention (e.g., healthy eating, exercise, blood pressure monitoring). Content validity was confirmed by an expert panel, and reliability testing yielded a Cronbach's $\alpha = 0.80$.

Ethical Considerations

Ethical approval was obtained from the Institutional Review Board of the College of Nursing, X University (IRB No. 3060026, dated 11-6-2023). Participants received detailed explanations about the study objectives, procedures, and their rights. Written informed consent was obtained before participation. Confidentiality and anonymity were strictly maintained, and participants were free to withdraw at any stage without penalty.

Data Analysis

Statistical analysis was performed using IBM SPSS Statistics version 25. Descriptive statistics (mean, standard deviation, and frequency) were used to summarize demographic and clinical data. Baseline equivalence between groups was examined using independent t-tests and chi-square tests. Mann–Whitney U and Wilcoxon signed-rank tests were used for non-normally distributed data to assess differences between and within groups. Independent t-tests compared pre- and post-intervention means for R-FSRP and HPLP-II scores. Spearman's correlation coefficients assessed associations between stroke risk and health-promoting behaviors. A p-value $< .05$ was considered statistically significant.

Results

Table 1 presents the sociodemographic and clinical characteristics of participants in both groups. The mean age did not differ significantly between groups ($p = .391$), although the intervention group included a higher proportion of females and illiterate participants. Differences were also observed in the prevalence of diabetes mellitus, cardiac disease, and atrial fibrillation.

Table 2 compares mean stroke risk scores between groups. The intervention group showed a significant reduction in stroke risk post-intervention ($p = .001$), while no change was noted in the control group.

Table 3 illustrates changes in stroke prevention practice levels before and after the intervention. A significant improvement was observed in the intervention group, with the proportion of participants demonstrating good practice increasing from 7.1% to 55.3% ($p < .001$).

Table 4 presents pre- and post-test scores for health-promoting lifestyle behaviors aligned with the 4Ms framework. Significant improvements were noted across all domains, with

Table 5 summarizes the correlations between stroke risk and health-promoting lifestyle behaviors. Negative correlations indicate that better health behaviors were associated with lower stroke risk, particularly in health responsibility, nutrition, and stress management domains.

Discussion

This randomized controlled trial demonstrated that a nurse-led, age-friendly educational program, grounded in the “4Ms” framework What Matters, Medication, Mentation, and Mobility significantly reduced stroke risk and enhanced health-promoting behaviors among older adults. The results affirm the effectiveness of incorporating age-friendly principles into preventive nursing interventions to promote healthy ageing and reduce the burden of stroke, particularly in low-resource settings.

Interpreting the Primary Outcome: Nurse-Led Reduction in Stroke Risk

The authors interpret the significant decline in the Revised Framingham Stroke Risk Profile (R-FSRP) scores observed in the intervention group as empirical support for the central role of nursing-led health education in stroke prevention. This outcome aligns with prior international evidence that up to 80% of first strokes can be prevented through lifestyle modification and risk management (Feigin et al., 2023; O’Donnell et al., 2016). Furthermore, the dramatic improvement in good stroke prevention practices from 7.1% to 55.3% underscores the importance of structured, literacy-appropriate education and follow-up, highlighting nurses' capacity to bridge the gap between health knowledge and consistent health behaviors (Govori et al., 2024; Kim et al 2023).

Exploring the Mechanism of Change: The 4Ms Framework

The authors attribute the positive results to the holistic nature of the intervention, with improvements observed across all Health-Promoting Lifestyle Profile II (HPLP-II) domains, especially physical activity, nutrition, and stress management. This suggests that the 4Ms framework effectively operationalizes key health promotion principles within gerontological nursing practice.

The “What Matters” element was instrumental in fostering motivation and adherence, as it anchored education to participants’ personal values and life priorities. This personalized approach resonates with findings that care aligned with older adults’ goals enhances engagement and self-efficacy (Mate et al., 2021). Similarly, the integration of “Mobility” and “Mentation” strengthened outcomes by addressing physical activity and cognitive well-being factors known to be interdependent in healthy ageing (Wong et al., 2022; Sadaqa et al., 2023). These findings are consistent with international studies reinforcing that

nurse-led, culturally tailored education is a powerful strategy for behaviour change among older adults managing chronic diseases (Zheng et al., 2020; Kim et al., 2023).

Considering Contextual and Cultural Factors

The authors contextualize the findings within the Egyptian setting, where the study extends the global evidence base to a Low- to Middle-Income Country (LMIC). The success of the intervention directly addresses the challenge of poor stroke awareness previously highlighted in the region (Shehata et al., 2022). Furthermore, the study suggests that cultural and gender factors may have influenced adherence. For instance, the traditional caregiving role of women in Egyptian culture may facilitate adherence to self-care behaviors like stress management, while cultural or environmental restrictions on outdoor activity may necessitate context-specific adaptations, such as home-based exercise plans. The authors conclude that cultural and gender considerations are essential when designing age-friendly programs in diverse LMICs.

Examining Distinctions and Alternative Explanations

The authors note that the comprehensive integration of the 4Ms framework provided a distinct, multidimensional approach to health that addressed psychosocial determinants, differentiating it from traditional stroke prevention models. This may explain the greater adherence observed here compared to more modest adherence reported in some European stroke prevention programs (Lennon et al., 2021). However, the authors acknowledge potential alternative explanations for the improvements, including the Hawthorne effect (modifying behavior due to being observed) and social desirability bias (inflated self-reports of healthy behaviors). Small, non-significant baseline differences and the possibility of regression to the mean are also possibilities that must be considered when interpreting the results.

Implications for Nursing Practice

These findings provide a strong theoretical contribution to gerontological nursing by illustrating how the 4Ms framework can be translated into measurable health outcomes in community-based practice. The authors propose the following implications for practice:

- Nurse-led educational programs anchored in the 4Ms framework offer a feasible and scalable model for promoting stroke prevention and health-promoting behaviors in older adults across outpatient and community settings (Greenberg et al, 2025).
- Integrating "What Matters" conversations into routine nursing assessments is essential for enhancing patient engagement, aligning goals, and improving adherence to preventive recommendations (Krist et al, 2017).
- Embedding the 4Ms into continuing nursing education is necessary to strengthen nurses' competencies in motivational communication, behavioral counselling, and holistic gerontological care, supporting the shift toward person-centered, preventive care (Pakkonen et al, 2021).

- Policymakers and healthcare leaders should prioritize the institutionalization of age-friendly, nurse-led interventions within national health strategies to reduce the burden of stroke and chronic diseases in ageing populations (Ruksakulpiwat et al, 2025).

Strengths and Limitations

This study provides novel empirical evidence on the operationalization of the 4Ms framework within an LMIC context, which is a significant addition to the limited global literature. The use of a randomized controlled trial design substantially enhances the internal validity and causal inference of the findings. Further strengths include the culturally adapted and literacy-appropriate intervention content and the utilization of validated instruments with strong reliability, contributing to methodological rigor.

The primary limitation is the relatively short follow-up period (16 weeks), which restricts definitive conclusions regarding the long-term sustainability of behavioral changes and stroke risk reduction. Secondly, the reliance on self-reported behavioral data introduces a risk of response and social desirability bias. Although the R-FSRP included objective clinical indicators, future studies should integrate objective behavioral assessments (e.g., accelerometer-measured physical activity or home blood pressure logs) to validate self-reports. Finally, minor, non-significant baseline differences in education and comorbidity, and the single-site nature of the study, may limit the generalizability of the findings to other regions or healthcare systems.

Conclusion and Recommendations

This study provides compelling evidence that a nurse-led, 4Ms-based educational program effectively reduces stroke risk and enhances health-promoting behaviors among older adults. By integrating the “What Matters,” “Medication,” “Mentation,” and “Mobility” domains, the intervention offers a comprehensive, person-centered model of preventive care that aligns with the principles of age-friendly health systems.

The findings lead to clear recommendations across three domains: Clinical Practice, Nursing Education, and Health Policy, supported by a need for future research. Healthcare institutions should immediately incorporate the 4Ms framework into routine assessments to ensure holistic, patient-centered care. Concurrently, nursing curricula and professional development programs should embed the 4Ms model and stroke prevention strategies. Policymakers must support the implementation of nurse-led, age-friendly programs at national and community levels to reduce preventable stroke. Finally, future research should focus on longitudinal and multi-center studies to evaluate long-term effectiveness, cost-efficiency, and scalability of 4Ms-based interventions in diverse healthcare contexts.

Declarations

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.

Consent for publication

Not applicable

Availability of data and materials

Data are available from the corresponding author upon reasonable request. Confidentiality and security of data and materials were ensured through all stages of the study.

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Patient and Public Involvement

Patients or members of the public were not involved in the design, conduct, reporting, or dissemination plans of our research.

Authors' Contributions

- **(X1):** Conceptualization, Methodology, Validation, Formal analysis, Investigation, Data curation, Writing – Original Draft, Writing – Review & Editing.
- **(X2):** Conceptualization, Methodology, Validation, Formal analysis, Investigation, Resources, Data curation.
- **(X3):** Conceptualization, Methodology, supervision, Validation, Formal analysis, Investigation, Resources, Data curation.

All authors have read and approved the final version of the manuscript.

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Tables

Table 1. Sociodemographic and clinical characteristics of participants (N = 170)

Variable	Intervention group (n = 85)	Control group (n = 85)	p-value[1]
Age (years), mean ± SD	66.52 ± 4.73	65.87 ± 5.07	.391
Sex, female n (%)	44 (51.8)	28 (32.9)	.013*
Educational level, illiterate n (%)	45 (52.9)	19 (22.4)	<.001**
Hypertension n (%)	65 (76.5)	72 (84.7)	.175
Diabetes mellitus n (%)	49 (57.6)	31 (36.5)	.006**
Cardiac disease n (%)	14 (16.5)	31 (36.5)	.003**
Atrial fibrillation n (%)	5 (5.9)	22 (25.9)	<.001**

Note. Values are mean ± standard deviation or number (percentage). ¹p-values calculated using independent t-test or χ^2 test as appropriate. $p < .05$*, $p < .01$**, statistically significant.

Table 2. Comparison of mean stroke risk scores (Revised Framingham Stroke Risk Profile) before and after intervention

Time point	Intervention mean ± SD	Control mean ± SD	p-value¹	Within-group p-value
Baseline	0.11 ± 0.08	0.17 ± 0.15	.113	—
Post-intervention	0.07 ± 0.04	0.17 ± 0.16	<.001**	.001** (intervention); .970 (control)

Note. Lower scores indicate reduced 10-year stroke risk. ¹Independent t-test comparing groups at each time point.

Table 3. Distribution of stroke-prevention practice levels pre- and post-intervention

Practice level	Pre-intervention n (%)	Post-intervention n (%)	p-value¹
Poor	61 (71.8)	13 (15.3)	<.001***
Fair	18 (21.2)	25 (29.4)	
Good	6 (7.1)	47 (55.3)	

Note. ¹χ^2 test comparing distributions pre- and post-intervention within the intervention group. $p < .001$*** indicates highly significant improvement in stroke-prevention practices.

The largest changes in physical activity and nutrition (both $p < .001$).

Table 4. Changes in health-promoting lifestyle behaviors (aligned with the 4Ms framework)

Domain	Pre-test mean ± SD	Post-test mean ± SD	p-value¹
Spiritual growth	2.22 ± 0.48	2.59 ± 0.34	<.001***
Health responsibility	1.96 ± 0.45	2.46 ± 0.37	<.001***
Physical activity	1.46 ± 0.45	2.17 ± 0.39	<.001***
Nutrition	1.43 ± 0.31	2.23 ± 0.42	<.001***
Interpersonal relations	2.12 ± 0.50	2.45 ± 0.30	<.001***
Stress management	1.82 ± 0.45	2.39 ± 0.38	<.001***

Note. Higher scores indicate greater engagement in health-promoting behaviors. ¹Wilcoxon signed-rank test comparing pre- and post-intervention scores.

Table 5. Correlations between stroke risk and health-promoting lifestyle behaviors among older adults

HPLP-II domain	Intervention r (pre)	Intervention r (post)	Control r (pre)	Control r (post)
Spiritual growth	−.257*	−.058	−.177	−.210
Health responsibility	−.218*	−.156	−.390***	−.406***
Physical activity	−.195	−.082	−.281**	−.334**
Nutrition	−.108	−.080	−.645***	−.588***
Interpersonal relations	−.265*	−.024	−.379***	−.376***
Stress management	−.276*	−.117	−.385***	−.371***

Note. r = Spearman correlation coefficient; negative correlations indicate lower stroke risk with higher health-promoting behaviors. $p < .05$*, $p < .01$**, $p < .001$***.