Effects of the Nurse-led Program on Disability Improvement in Patients with Stroke: A Systematic Review and Meta-analysis

Khalid Abdullaha Aljohani1, Hammad Ali Fadlalmola1,* and Doaa El Sayed Fadila1,2

1Department of Community Health Nursing, College of Nursing, Taibah University, Medina, Saudi Arabia
2Gerontological Nursing Department, Faculty of Nursing, Mansoura University, Mansoura, Egypt

Correspondence to:
Hammad Ali Fadlalmola*, e-mail: hazzminno345@gmail.com; hafadlelmola@taibahu.edu.sa, Tel.: 00966504900120

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ABSTRACT
Stroke holds the third position globally as a cause of combined morbidity and mortality, presenting a dire prognosis. This study aims to investigate the hypothesis that nurse-led rehabilitation and follow-up programs offer a significant improvement in motor disability outcomes in post-stroke patients compared to standard care. Eligibility criteria required primary studies providing data on post-stroke patients managed via nurse-led programs or standard care. Comprehensive searches were conducted across several databases until June 2023. The bias and quality of the included studies were assessed using appropriate tools. Our study analyzed a total of 16 studies involving 2072 patients. The findings suggested that nurse-led programs significantly correlate with overall motor disability improvements compared to standard care, as reflected by higher Barthel index (BI) scores, improved modified BI scores, and reduced proportions of patients with a modified Rankin scale of >2. Nurse-led programs are associated with overall improvements in motor disability in post-stroke patient management and follow-up, proving to be more effective than standard care. We recommend that the nurse-led programs be clearly defined, isolated from the multidisciplinary teams, and specified in one study arm to draw significant results regarding their roles in managing post-stroke patients.

KEYWORDS
meta-analysis, nursing, nurse-led program, stroke, systematic review, motor disability

INTRODUCTION
Stroke prevalence exceeded 100 million in 2019; it remained the global second most common cause of morbidity and the global third cause of combined disability and morbidity (GBD 2019 Stroke Collaborators, 2021). Since the 1990s, the incidence and prevalence of stroke have increased by about 70 and 85%, respectively (GBD 2019 Stroke Collaborators, 2021). Additionally, an increase in stroke-associated deaths was estimated to be about 43%, advanited by the fact of being more prevalent among the elderly population (GBD 2019 Stroke Collaborators, 2021; Feigin et al., 2022).

The prognosis of stroke is considered bleak, with approximately 33% of stroke patients becoming either disabled or dead in 1 year (Wu et al., 2019). Adverse events of stroke vary widely, including recurrent stroke (Esenwa and Gutierrez, 2015; Kolmos et al., 2021), dementia (Hénon et al., 2006; Pendlebury and Rothwell, 2009), impaired cognition, falls (Kanis et al., 2001), and seizures (Bladin et al., 2000; Langhorne et al., 2000). Moreover, post-stroke brain infarcts mostly affect the brain centers for motor activity and the corticospinal tract, resulting in debilitated motor function (Pramanick et al., 2020). Also, essential daily activities are widely compromised, including eating, drinking, voiding, defecation, getting dressed, maintaining personal hygiene, and taking care of one’s appearance (Legg et al., 2017; Cumming et al., 2019).

Motor ability is the capacity to perform movements that require coordination, strength, balance, and precision. Paralysis is the loss of muscle function in one or more parts of the body due to nerve damage. Both motor ability and paralysis can be caused by stroke. Motor ability is a multidimensional concept that can vary across stroke patients.

Nurse-led programs are an innovative and effective way to deliver high-quality health care to various patient populations. By utilizing the skills and expertise of nurses, these programs can improve patient outcomes, satisfaction, and empowerment, as well as reduce health-care costs and
resource utilization. Nurse-led programs can also address the challenges of health-care systems, such as workforce shortages, access barriers, and rising demands. Therefore, nurse-led programs should be supported and expanded to enhance the health and well-being of individuals and communities (Khair and Chaplin, 2017).

Prior studies demonstrated that the nurse-led programs provided substantial benefits in rehabilitating disabled patients after acute ischemic stroke (Mendyk et al., 2018; Lin et al., 2020; Verberne et al., 2020). Their role became crucial in rural and resource-limited areas where a marked shortage of rehabilitation therapists was found compared to the developed countries (Gimigliano and Negrini, 2017). They were involved in different aspects with respect to the management of patients post-stroke, including exerting actual rehabilitation practice without the supervision of therapists (Langhorne et al., 2010; Dorsch et al., 2019; Li et al., 2021). Moreover, they educated the patients and their caregivers in various settings: inpatient (Ademuyiwa and Okubadejo, 2021; Urcan and Kolcu, 2022), telephone-based (Ademuyiwa and Okubadejo, 2021; Cha et al., 2022), home visits (Mao et al., 2022), or outpatient clinics (Wang et al., 2022b). Additionally, they provided regular follow-ups for patients and their caregivers to address their concerns (McAlister et al., 2014).

Published literature suggested that nurse-led stroke management was reported with either a positive effect of the nurse-led programs or a nonsignificant effect between the studies’ arms. Additionally, no previous meta-analysis (MA) investigated the nurse-led programs versus the usual care concerning the management of post-stroke patients (Langhorne et al., 2010; Yue et al., 2013; McAlister et al., 2014; Wong and Yeung, 2015; Zhou et al., 2019; Li et al., 2021; Wang et al., 2021, 2022a; Ai et al., 2022; Cha et al., 2022; Deng et al., 2022; Zheng et al., 2023).

Thus, we aimed to gather the available evidence, investigate the overall positive or negative tendency of nurse-led management and follow-up for stroke patients with disability, and execute a comparative analysis with the usual care regarding the outcome measures of the motor disability where possible. We hypothesized that the nurse-led rehabilitation and follow-up programs are associated with an overall improvement in motor disability compared to the usual care that they would generally receive after a stroke, according to the current practice and guidelines. It may include physical and occupational therapy, speech therapy, swallowing and respiratory therapy, mental health counseling, medication instructions, follow-up visits, and routine counseling.

METHODS

Study design

Our systematic review (SR) and MA were guided by the Cochrane Handbook instructions (Higgins et al., 2022) and tracked using Preferred Reporting Items for Systematic Reviews and Meta-Analyses 2020 (PRISMA) (Page et al., 2021).

Search strategy and data collection

We searched Embase, Scopus, Cochrane Library, PubMed, and Web of Science until June, 2023; using the following keywords: (“Nurse-led” OR “Nurse led” OR “nurse based” OR “nurse-based” OR “Nurse*” OR “Nursing”) AND (stroke OR poststroke OR “Post-stroke” OR “Cerebrovascular Accident*” OR CVA OR CVAs OR “Cerebrovascular Apoplexy”). We modified the inserted terms according to the recommendations of each searched database. The retrieved studies were gathered using Endnote version 20 to omit duplicates and then exported to an Excel sheet for screening.

Eligibility criteria

Studies that matched the upcoming criteria were eligible for our SR and MA: population: patients with stroke; intervention: nurse-led program; comparison: usual care; outcomes: any relevant outcomes. Certain studies were excluded from our analysis based on the following reasons: (i) studies not published in the English language; (ii) studies comprising solely of abstracts; and (iii) single-arm or review studies.

Data extraction

We extracted the data about the summary of the retrieved studies and characteristics of the enrolled population: Study ID (last name of the first author and publication year), study arms and number of enrolled cases in each, study location, study design, age, (mean ± SD), sex, follow-up duration (months), education level, past medical history, stroke types, inclusion criteria, primary endpoints, and conclusion. They also extracted data regarding measures of motor disability, including the Barthel index (BI), the modified Rankin scale (mRS), EuroQol-5-dimension (EQ-5D), and the modified BI.

Disability measures

- **Barthel index (BI):**
  Mahoney and Barthel created the index in the mid-1960s (Mahoney and Barthel, 1965). It was a scale of 10 items that assessed the degree of independence. Each item was categorized into three levels: fully independent, requires assistance, and failed to do the task (Mahoney and Barthel, 1965; Shah et al., 1989).
- **Modified Barthel index (BI):**
  The modified BI was created in the late 1980s (Shah et al., 1989) and consisted of the same 10 items of the BI. However, each item was categorized into five: fully independent, failed to do the task, and three levels of required assistance. A higher score means better motor function in both BI and modified BI.
- **EuroQol-5-dimension (EQ-5D):**
  The EQ-5D is one of the most common indices that assess the quality of life (The EuroQol Group, 1990; Brooks, 1996; Rabin and de Charro, 2001). It consists of five dimensions: level of mobility, self-care, engagement in
regular activities, experience of pain, and presence of depression or anxiety. The respondents choose the answer that best reflects their health state regarding each dimension: no problems, some problems, or severe problems. The overall score of the EQ-5D index ranges from 0 to 1, interpreted by a range from the worst possible health state to full health, respectively.

- Modified Rankin Scale (mRS):
  It is a widely used scale that assesses the motor disability of patients suffering from neurological debilitating diseases, especially stroke. Its score ranges from 0 to 6, interpreted by a range from the normal health state to dead. Scores from 1 to 5 could be categorized into <2 and >2, interpreted as mild disability or moderate to severe disability, respectively (Langhorne et al., 2010; Cha et al., 2022; Deng et al., 2022).

Quality assessment

The designs of the included studies were clinical trials, cohorts, or quasi-experimental studies. The methodological quality of the clinical trials was appraised using the Cochrane tool (Higgins et al., 2011), which includes the subsequent domains: random selection, concealed allocation, blinding of participants, personnel and outcome assessors, attrition, and reporting bias. Each domain was labeled by low-risk, high-risk, or unclear bias. The quality of the cohort study was appraised using the NIH assessment tool (National Institutes of Health, 2014). It consisted of 14 questions that assessed different aspects of study design, data collection, and analysis. Each question is answered by either yes, no, or nonavailable. Quasi-experimental studies by Ademuyiwa and Okubadejo (2021) and Zheng et al. (2023) were assessed using the relevant items from the Downs and Black checklist (Downs and Black, 1998).

Data analysis

Analysis of the pooled data was done using RevMan version (5.4). Our study reported the continuous data as mean difference (MD) and 95% confidence interval (CI) but the dichotomous data as risk ratio (RR). Between studies, heterogeneity was determined using the Cochrane Q test based on Chi-square distribution. Significant heterogeneity was considered if the P value of the Q test was <0.1. Additionally, heterogeneity was quantified using the I-squared ($I^2$) test; it was considered significant if the $I^2$ value was >50%. We applied the random effect model and the leaving one out method to resolve the heterogeneity regarding each outcome measure when possible. Otherwise, the homogenous studies were treated by applying the fixed effect model.

RESULTS

Literature search

Our literature search initially found 821 studies: 467 studies were omitted as duplicates, leaving 354 studies that were screened for relevancy. We finally included a total of 16 studies (Langhorne et al., 2010; Kim, 2012; Yue et al., 2013; McAlister et al., 2014; Wong and Yeung, 2015; Zhou et al., 2019; Ademuyiwa and Okubadejo, 2021; Li et al., 2021; Wang et al., 2021, 2022a,b; Ai et al., 2022; Cha et al., 2022; Deng et al., 2022; Urcan and Kolcu, 2022; Zheng et al., 2023). Out of them 12 were chosen for SR and MA (Langhorne et al., 2010; Yue et al., 2013; McAlister et al., 2014; Wong and Yeung, 2015; Zhou et al., 2019; Li et al., 2021; Wang et al., 2021, 2022a,b; Ai et al., 2022; Cha et al., 2022; Deng et al., 2022; Zheng et al., 2023), contrary to four studies that were only eligible for SR (Kim, 2012; Ademuyiwa and Okubadejo, 2021; Urcan and Kolcu, 2022; Wang et al., 2022b). A detailed flow of the literature review is presented in Figure 1 (Page et al., 2021).

Baseline characteristics of the included population

Our study finally included a total of 16 studies with overall 2072 enrolled patients; the studies were primarily clinical trials (Langhorne et al., 2010; Kim, 2012; Yue et al., 2013; McAlister et al., 2014; Wong and Yeung, 2015; Zhou et al., 2019; Li et al., 2021; Wang et al., 2021, 2022a,b; Ai et al., 2022; Cha et al., 2022; Urcan and Kolcu, 2022) in addition to only one cohort study (Deng et al., 2022) and two quasi-experimental studies (Ademuyiwa and Okubadejo, 2021; Zheng et al., 2023). The included studies were conducted in China, Canada, Australia, Sweden, Nigeria, the UK, and South Korea. The enrolled population’s mean age varied from mid-50s to mid-70s, with most of the population falling within the age bracket of 60s. Detailed characteristics of the eligible studies are presented in Table 1.

Risk of bias assessment

With respect to randomized clinical trials, appraisal of most domains denoted an overall low-risk bias. However, assessment of the performance bias domain revealed either high-risk or unclear bias (Fig. 2). In the study by Deng et al. (2022), the only included cohort study, the NIH tool (National Institutes of Health, 2014) was used for assessment and showed an overall fair methodological quality with a total score of nine (Supplementary Table S1). The included quasi-experimental studies by Ademuyiwa and Okubadejo (2021) and Zheng et al. (2023) were assessed by the relevant items from the Downs and Black checklist (Downs and Black, 1998) and showed an overall good quality (Supplementary Table S2).

Quantitative analysis (outcomes)

Modified Barthel index

Pooled data from five studies (Yue et al., 2013; Wong and Yeung, 2015; Wang et al., 2021, 2022a,b; Deng et al., 2022) with a total of 586 patients showed that the score of modified
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BI was significantly higher in nurse-led programs when compared to the usual care (MD = 10.33; 95% CI = 3.10-17.57; \( P = 0.005 \)) (Fig. 3).

Initial inter-studies heterogeneity was discovered \( (I^2 = 73\%) \) but finally mitigated by excluding Deng et al. \( (I^2 = 35\%) \) (Deng et al., 2022) (Fig. 4).

**Barthel index (BI)**

Data pooled from four included studies with a total of 684 patients (Zhou et al., 2019; Li et al., 2021; Ai et al., 2022; Zheng et al., 2023) revealed a statistically significant superiority of the nurse-led programs when compared to usual care (MD = 7.06; 95% CI = 1.33-12.79; \( P = 0.02 \)). Inter-studies heterogeneity was found and could not be resolved \( (I^2 = 85\%) \) (Fig. 5).

**Modified Rankin scale (mRS)**

We categorized the scale into two categories: up to mild disability \( (\text{mRS} \leq 2) \) and moderate to severe disability \( (\text{mRS} > 2) \), guided by Cha et al. (2022) and Deng et al. (2022).

- **mRS \leq 2**
  
  Analysis of 561 patients’ data gathered from four studies (Langhorne et al., 2010; Zhou et al., 2019; Cha et al., 2022; Deng et al., 2022) showed a numerical superiority of nurse-led programs compared to usual care. However, it was statistically nonsignificant \( (\text{RR} = 1.43; 95\% \text{ CI} = 0.98-2.10; P = 0.06) \). Additionally, initial inter-studies heterogeneity was found \( (I^2 = 81\%) \) but could be resolved upon the exclusion of Zhou et al. (2019) \( (I^2 = 0\%) \) (Figs. 6 and 7, respectively).

- **mRS > 2**
  
  The pooled data from Cha et al. (2022), Deng et al. (2022), and Langhorne et al. (2010) showed that moderate to severe disabilities were significantly lower in the nurse-led program than the usual care \( (\text{RR} = 0.60; 95\% \text{ CI} = 0.48-0.76; P < 0.000) \). The meta-analyzed studies were homogenous \( (I^2 = 0\%) \) (Fig. 8).

**EuroQol-5-dimension (EQ-5D)**

The comparative analysis of data gathered from three studies (Kerry et al., 2013; McAlister et al., 2014; Zhou et al., 2019) showed no significant difference between the nurse-led program and the usual care regarding the quality of life \( (\text{MD} = -0.02; 95\% \text{ CI} = -0.08 \text{ to } 0.04; P = 0.54) \). We identified initial substantial heterogeneity among the studies \( (I^2 = 74\%) \), which was finally mitigated by excluding the study by Zhou et al. (2019) \( (I^2 = 0\%) \) (Figs. 9 and 10, respectively).
Table 1: Summary and baseline characteristics of the included studies.

<table>
<thead>
<tr>
<th>Study ID</th>
<th>Study arms, n (%)</th>
<th>Site</th>
<th>Study design</th>
<th>Age, (mean ± SD) years</th>
<th>Male, n (%)</th>
<th>Follow-up duration (months)</th>
<th>Education level, n (%)</th>
<th>Past medical history, n (%)</th>
<th>Stroke types, n (%)</th>
<th>mRS at discharge, n (%)</th>
<th>Inclusion criteria</th>
<th>Primary endpoints</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ademuyiwa et al., 2023</td>
<td>Nurse led, 30 (50%)</td>
<td>Nigeria</td>
<td>Quasi-experimental design</td>
<td>55 ± 14.5</td>
<td>22</td>
<td>3.9</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2.2 (SD 1)</td>
<td>(i) Carried out in Lagos University Teaching Hospital, (ii) Consecutive stroke survivors at discharge, (iii) Care conducted over the initial 3 months to enable follow-up for at least 9 months.</td>
<td>(i) Lifestyle modification, (ii) Diet modification, (iii) Clinical and physical attendance, (iv) Drug compliance.</td>
<td>This study demonstrates the potential utility of a nurse-led intervention incorporating targeted lifestyle risk modification on compliance to strategies to reduce stroke recurrence. Adoption of this task shifting/sharing strategy is recommended.</td>
</tr>
<tr>
<td>Usual care, 30 (50%)</td>
<td></td>
<td></td>
<td></td>
<td>56 ± 11.2</td>
<td>17</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2.6 (SD 1.2)</td>
<td>(i) Modifications of clinical efficacy, (ii) Changes in blood glucose, (iii) Changes in body temperature, (iv) Comparisons of swallowing function.</td>
<td></td>
<td>Multidisciplinary nursing based on fewer, blood sugar, and swallowing function management for patients with AS improves the clinical outcome and treatment efficiency, restores the swallowing function and blood glucose level, andameliorates the long-term prognosis of patient.</td>
</tr>
<tr>
<td>Ai et al., 2022</td>
<td>Nurse led, 100 (50%)</td>
<td>China</td>
<td>RCT</td>
<td>67.18 ± 11.84</td>
<td>56 (56%)</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>(i) Modified mRS stroke, 20 (29%); (ii) Hemorrhagic stroke, 71 (71%)</td>
<td>(i) Patients with acute stroke between 2019 and 2020, (ii) Participated in an education program for stroke rehabilitation.</td>
<td>With an mRS score of 0-3. A telehphone-based in intervention improved PA 3 months after stroke. Further studies with larger sample sizes and long-term follow-up is needed.</td>
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<tr>
<td>Usual care, 100 (50%)</td>
<td></td>
<td></td>
<td></td>
<td>68.56 ± 13.57</td>
<td>68 (68%)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>(i) Ischemic stroke, 23 (23%); (ii) Hemorrhagic stroke, 77 (77%)</td>
<td>(i) Diagnosed with AS by clinical and imaging examinations, (ii) 18-80 years, with a time-lapse from onset to randomization, (iii) With tolerance to nursing measures such as oral examination and sampling.</td>
<td>(i) Comparisons of clinical efficacy, (ii) Changes in blood glucose, (iii) Changes in body temperature, (iv) Comparisons of swallowing function.</td>
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<td></td>
</tr>
<tr>
<td>Cha et al., 2022</td>
<td>Nurse led, 73 (52.51%)</td>
<td>South Korea</td>
<td>RCT</td>
<td>63.7 ± 12.8</td>
<td>53</td>
<td>72.6%</td>
<td>All at least 3</td>
<td>(i) Ischemic stroke, 63 (86.5%); (ii) Hemorrhagic stroke, 10 (13.7%)</td>
<td>(i) HTN, 77 (81.8%); (ii) DM, 20 (27.4); (iii) AF, 10 (13.7%); (iv) Previous stroke, 12 (16.4%)</td>
<td>(i) 0.25 (25%); (ii) 1.0, 2.5 (25%); (iii) 3.5, 17 (17%)</td>
<td>(i) Diagnosed with AS by clinical and imaging examinations, (ii) 18-80 years, with a time-lapse from onset to randomization, (iii) With tolerance to nursing measures such as oral examination and sampling.</td>
<td>(i) Comparisons of clinical efficacy, (ii) Changes in blood glucose, (iii) Changes in body temperature, (iv) Comparisons of swallowing function.</td>
<td>(i) Patients with acute stroke between 2019 and 2020. (ii) Participated in an education program for stroke rehabilitation. (iii) With an mRS score of 0-3. A telehphone-based in intervention improved PA 3 months after stroke. Further studies with larger sample sizes and long-term follow-up is needed.</td>
</tr>
<tr>
<td>Usual care, 66 (47.49%)</td>
<td></td>
<td></td>
<td></td>
<td>65.1 ± 13</td>
<td>43</td>
<td>65.2%</td>
<td>All at least 3</td>
<td>(i) Ischemic stroke, 60 (90.9%); (ii) Hemorrhagic stroke, 6 (9.1%)</td>
<td>(i) HTN, 48 (72.7%); (ii) DM, 22 (33.3%); (iii) AF, 7 (10.6%); (iv) Previous stroke, 12 (18.2%)</td>
<td>(i) 0-0.4 (24%); (ii) 1, 26 (26%); (iii) 21 (21%); (iv) 3.5; 29 (29%)</td>
<td>(i) Diagnosed with AS by clinical and imaging examinations, (ii) 18-80 years, with a time-lapse from onset to randomization, (iii) With tolerance to nursing measures such as oral examination and sampling.</td>
<td>(i) Comparisons of clinical efficacy, (ii) Changes in blood glucose, (iii) Changes in body temperature, (iv) Comparisons of swallowing function.</td>
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</tr>
<tr>
<td>Deng et al., 2022</td>
<td>Nurse led, 57 (50%)</td>
<td>China</td>
<td>Prospective cohort study</td>
<td>38</td>
<td>38</td>
<td>66.7%</td>
<td>All at least 3</td>
<td>(i) Illiteracy, 1 (18.1%); (ii) Primary school, 17 (23.9%); (iii) Junior high school, 19 (23.3%); (iv) High school, 12 (15.8%); (v) University, 8 (17.3%)</td>
<td>(i) HTN, 44 (77.2%); (ii) DM, 16 (28.1%); (iii) AF or WHD, 2 (3.5%); (iv) Hypertension, 18 (31.6%); (v) Overweight or obese, 21 (36.8%); (vi) Smoking, 22 (36.8%); (vii) Lack of physical exercise, 42 (73.7%); (viii) HTN, 45 (78.9%); (ix) DM, 21 (36.8%); (x) AF or WHD, 12 (21.3%); (xi) Hypertension, 15 (26.3%); (xii) Overweight or obese, 21 (36.8%); (xiii) Smoking, 29 (50.9%); (xiv) Lack of physical exercise, 27 (47.4%)</td>
<td>(i) Diagnosed with AS by clinical and imaging examinations, (ii) 18-80 years, with a time-lapse from onset to randomization, (iii) With tolerance to nursing measures such as oral examination and sampling.</td>
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<tr>
<td>Usual care, 57 (50%)</td>
<td></td>
<td></td>
<td></td>
<td>38</td>
<td>47</td>
<td>82.3%</td>
<td>All at least 3</td>
<td>(i) Illiteracy, 2 (3.5%); (ii) Primary school, 9 (15.8%); (iii) Junior high school, 32 (56.1%); (iv) High school, 9 (15.8%); (v) University, 5 (8.8%)</td>
<td>(i) HTN, 44 (77.2%); (ii) DM, 16 (28.1%); (iii) AF or WHD, 2 (3.5%); (iv) Hypertension, 18 (31.6%); (v) Overweight or obese, 21 (36.8%); (vi) Smoking, 22 (36.8%); (vii) Lack of physical exercise, 42 (73.7%); (viii) HTN, 45 (78.9%); (ix) DM, 21 (36.8%); (x) AF or WHD, 12 (21.3%); (xi) Hypertension, 15 (26.3%); (xii) Overweight or obese, 21 (36.8%); (xiii) Smoking, 29 (50.9%); (xiv) Lack of physical exercise, 27 (47.4%)</td>
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<th>Study ID</th>
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<th>Follow-up duration (months)</th>
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<th>Inclusion criteria</th>
<th>Primary end points</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kim et al., 2012</td>
<td>Nurse led, 20 (44.44%)</td>
<td>RCT</td>
<td>61.70 ± 10.18</td>
<td>14 (70%)</td>
<td>Mean (4.21)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>(i) Were in the rehabilitation unit and had been diagnosed with stroke. (ii) Had mild to moderate limb movement limitation on one side. (iii) Had no serious perceptual or cognitive dysfunction.</td>
<td>(i) Functional status, (ii) Fatigue, (iii) Sleep disturbance. (iv) Depression</td>
<td>Safe and enjoyable nursing interventions should be developed and implemented to improve disability and related problems for the post-stroke inpatients.</td>
</tr>
<tr>
<td></td>
<td>Usual care, 25 (55.56%)</td>
<td></td>
<td>55.52 ± 15.48</td>
<td>14 (56%)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Langhorne et al., 2010</td>
<td>Nurse led, 32 (50%)</td>
<td>Australia</td>
<td>RCT</td>
<td>64.33 ± 15.2</td>
<td>16 (50%)</td>
<td>Mean (3)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>(i) HTN, 1 (34.37%); (ii) AF, 1 (3.12%); (iii) CD, 7 (21.87%); (iv) DM, 4 (12.5%); (v) Previous stroke, 5 (15.63%); (vi) Current smoker, 11 (34.38%); (vii) AD, 6 (18.75%)</td>
<td>(i) Total ischemic stroke, 43 (71.67%); (ii) Hemorrhagic stroke, 17 (28.33%); (iii) Ischemic stroke, 44 (73.33%); (iv) Hemorrhagic stroke, 16 (26.67%)</td>
<td>Rankin (0-1), 90 (63%)</td>
</tr>
<tr>
<td></td>
<td>Usual care, 32 (50%)</td>
<td></td>
<td>67.84 ± 14.98</td>
<td>16 (50%)</td>
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<tr>
<td>Li et al., 2021</td>
<td>Nurse led, 60 (50%)</td>
<td>China</td>
<td>RCT</td>
<td>65.08 ± 3.47</td>
<td>36 (60%)</td>
<td>Mean (3)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>(i) Ischemic stroke, 11 (34.38%); (ii) AF, 1 (3.12%); (iii) CD, 7 (21.87%); (iv) DM, 5 (16.63%); (v) Previous stroke, 3 (9.38%); (vi) Current smoker, 15 (46.88%); (vii) AD, 10 (31.25%)</td>
<td>(i) Total AC stroke, 2 (6.25%); (ii) Partial AC stroke, 11 (34.38%); (iii) Lacunar stroke, 8 (25%); (iv) Other/unclassified, 11 (34.38%)</td>
<td>Rankin (0-1), 90 (63%)</td>
</tr>
</tbody>
</table>
Table 1: Continued.

<table>
<thead>
<tr>
<th>Study ID</th>
<th>Study arms, n (%)</th>
<th>Site</th>
<th>Study design</th>
<th>Age, (mean ± SD) years</th>
<th>Male, n (%)</th>
<th>Fol-low-up duration (months)</th>
<th>Education level, n (%)</th>
<th>Stroke types, n (%)</th>
<th>mRS at discharge, n (%)</th>
<th>Inclusion criteria</th>
<th>Primary endpoints</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urcan et al., 2022</td>
<td>Nurse-led, 46 (50%)</td>
<td>Turkey</td>
<td>RCT</td>
<td>55.37 ± 13.52</td>
<td>31 (67.4%)</td>
<td>Up to 17</td>
<td>-</td>
<td>Ischemic, 36 (78.3); (ii) Hemorrhagic, 10 (21.7)</td>
<td>-</td>
<td>Between March 2015 and March 2020. (i) With stroke patients who were treated at the physical rehabilitation. (ii) All stroke patients had written informed consent.</td>
<td>(i) Total RCSQ score. (ii) Sleep-related characteristics of stroke patients. (iii) Mobility. (iv) Upper extremity function.</td>
<td>In the posttest, the intervention group had significantly higher sleep quality and SSQOL scores than the control group. This study may serve as a guide for nurses who work with stroke patients.</td>
</tr>
<tr>
<td>Usual care, 46</td>
<td>(50%)</td>
<td></td>
<td></td>
<td>59.15 ± 11.56</td>
<td>25 (54.3%)</td>
<td></td>
<td>-</td>
<td>Ischemic, 36 (78.3); (ii) Hemorrhagic, 10 (21.7)</td>
<td>-</td>
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<tr>
<td>Wang et al., 2021</td>
<td>Nurse-led, 108 (51.67%)</td>
<td>China</td>
<td>RCT</td>
<td>64.35 ± 10.59</td>
<td>79 (73.1%)</td>
<td>1-3</td>
<td>-</td>
<td>Ischemic stroke 4 (IQR 4, 4)</td>
<td>-</td>
<td>Between 18 and 90 years old. (i) Diagnosed as having an ischemic stroke. (ii) Having an initial stroke within 7 days, with limb dysfunction. (iii) Having no contraindications for MRI examination.</td>
<td>(i) Motor assessment scale. (ii) Fugl-Meyer assessment scale. (iii) mRS.</td>
<td>Both treatments had comparable effects; however, no definite conclusion could be drawn. Adequately powered studies are required.</td>
</tr>
<tr>
<td>Usual care, 101</td>
<td>(48.33%)</td>
<td></td>
<td></td>
<td>61.36 ± 15.27</td>
<td>68 (67.3%)</td>
<td></td>
<td>-</td>
<td>Ischemic stroke 4 (IQR 3, 4)</td>
<td>-</td>
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<tr>
<td>Wang et al., 2022a</td>
<td>Nurse-led, 56 (56%)</td>
<td>China</td>
<td>RCT</td>
<td>66.3 ± 14.1</td>
<td>29 (53.7%)</td>
<td>Up to 6</td>
<td>-</td>
<td>Ischemic stroke 4 (IQR 3, 4)</td>
<td>-</td>
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<tr>
<td>Usual care, 54</td>
<td>(54%)</td>
<td></td>
<td></td>
<td>65.4 ± 13.7</td>
<td>30 (53.6%)</td>
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<td>-</td>
<td>Ischemic stroke 4 (IQR 3, 4)</td>
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</table>
## Table 1: Continued.

<table>
<thead>
<tr>
<th>Study ID</th>
<th>Study arms, n (%)</th>
<th>Site</th>
<th>Study design</th>
<th>Age, (mean ± SD) years</th>
<th>Male, n (%)</th>
<th>Follow-up duration (months)</th>
<th>Education level, n (%)</th>
<th>Past medical history, n (%)</th>
<th>Stroke types, n (%)</th>
<th>mRS at discharge, n (%)</th>
<th>Inclusion criteria</th>
<th>Primary endpoints</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wang et al., 2022b</td>
<td>Nurse led, 43 (48.86%)</td>
<td>China</td>
<td>RCT</td>
<td>64.35 ± 10.59</td>
<td>23 (46.9%)</td>
<td>Mean (7)</td>
<td>(i) Illiterate, 10 (23.3%); (ii) Primary school, 12 (27.9%); (iii) Junior high school, 8 (18.6%); (iv) High school, 13 (30.2%)</td>
<td>(i) Smoking, 17 (39.5%); (ii) CVA or TIA, 8 (18.6%); (iii) HTN, 24 (55.8%); (iv) DM, 11 (25.6%)</td>
<td>Ischemic stroke</td>
<td>-</td>
<td>(i) Aged 18 years or older; (ii) Diagnosed with ischemic stroke and met the diagnostic criteria of the WHO; (iii) Had initial stroke within 7 days with limb dysfunction.</td>
<td>(i) Modified BI. (ii) Motor assessment scale. (iii) NIHSS.</td>
<td>The nurse-led rehabilitation program used in this study was shown to be feasible and effective in improving motor function in patients with acute ischemic stroke. Further study is recommended to determine related clinical recommendations.</td>
</tr>
<tr>
<td>Usual care, 45 (51.14%)</td>
<td>61.36 ± 15.27</td>
<td>26 (53.1%)</td>
<td>(i) Illiterate, 7 (15.6%); (ii) Primary school, 14 (31.1%); (iii) Junior high school, 17 (37.8%); (iv) High school, 7 (15.5%)</td>
<td>(i) Smoking, 19 (42.2%); (ii) CVA or TIA, 8 (17.7%); (iii) HTN, 32 (71.1%); (iv) DM, 14 (31.1%)</td>
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<tr>
<td>Wong et al., 2014</td>
<td>Nurse led, 54 (50%)</td>
<td>China</td>
<td>RCT</td>
<td>67.5 ± 11.6</td>
<td>20 (37%)</td>
<td>At least 1</td>
<td>(i) No education, 9 (16.6%); (ii) Primary, 24 (44.4%); (iii) Secondary, 18 (33.3%); (iv) University, 3 (5.6%)</td>
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<td></td>
<td></td>
<td>(i) Hemothorax, 7 (13%); (ii) Ischemic, 47 (87%)</td>
<td>&lt;2</td>
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<tr>
<td>Usual care, 54 (50%)</td>
<td>71.5 ± 11.6</td>
<td>20 (37%)</td>
<td>(i) No education, 20 (37%); (ii) Primary, 21 (38.9%); (iii) Secondary, 12 (22.2%); (iv) University, 1 (1.9%)</td>
<td>(i) HTN, 24 (44.4%); (ii) DM, 16 (17.1%); (iii) HD, 17 (48.6%)</td>
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<td></td>
<td></td>
<td></td>
<td>(i) Hemothorax, 7 (13%); (ii) Ischemic, 47 (87%)</td>
<td></td>
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</tr>
<tr>
<td>Yue et al., 2012</td>
<td>Nurse led, 39 (50%)</td>
<td>China</td>
<td>RCT</td>
<td>68.8 ± 11.7</td>
<td>19 (54.2%)</td>
<td>Mean (3)</td>
<td>(i) Senior high school, 24 (68.6%); (ii) College level, 11 (32.4%)</td>
<td>(i) HTN, 22 (62.8%); (ii) DM, 14 (41.2%); (iii) HD, 16 (47.1%)</td>
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<tr>
<td>Usual care, 39 (50%)</td>
<td>68.8 ± 10.3</td>
<td>18 (53%)</td>
<td>(i) Senior high school, 22 (64.7%); (ii) College level, 12 (35.3%)</td>
<td>(i) HTN, 22 (62.8%); (ii) DM, 14 (41.2%); (iii) HD, 16 (47.1%)</td>
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<tr>
<td>Zheng et al., 2003</td>
<td>Nurse led, 60 (50%)</td>
<td>China</td>
<td>Quasi-experimental design</td>
<td>62.70 ± 12.52</td>
<td>41 (68.33%)</td>
<td>At least 1</td>
<td>(i) HTN, 33 (55%); (ii) DM, 15 (25%); (iii) AF, 6 (10%)</td>
<td>(i) Lacunar infarction, 25 (41.7%); (ii) Partial AC infarct, 13 (21.7%); (iii) Total AC infarct, 10 (16.7%); (iv) PC infarct, 12 (20%)</td>
<td></td>
<td></td>
<td></td>
<td>(i) 0.6 (10%); (ii) 1, 31 (51.67%); (iii) 2, 22 (56.67%)</td>
<td>(i) Between March 2009 and July 2010. (ii) Hemiplegic patients after stroke. (iii) Age range of 40 years or older. (iv) Able to communicate in a normal mental state. (v) Written informed consent was obtained.</td>
</tr>
<tr>
<td>Usual care, 60 (50%)</td>
<td>66.28 ± 10.02</td>
<td>43 (71.67%)</td>
<td>(i) HTN, 38 (63.3%); (ii) DM, 19 (31.7%); (iii) AF, 3 (5%)</td>
<td>(i) Lacunar infarction, 11 (18.3%); (ii) Partial AC infarct, 16 (26.7%); (iii) Total AC infarct, 11 (18.3%); (iv) PC infarct, 23 (36.67%)</td>
<td></td>
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<td></td>
<td>(i) 0.5 (8.33%); (ii) 1, 23 (38.33%); (iii) 2, 30 (50%)</td>
<td>(i) Swallowing function. (ii) Activities of daily living score.</td>
<td>Nurse-led hierarchical management care based on AIS-APS can reduce the incidence of SAP, promote AIS patients’ neurological function, and maintain patients’ ADL. The results of our study indicated that nurse-led hierarchical management care is feasible for AIS patients and provides individualized interventions for patients with different levels of SAP risk. Nurse-led hierarchical management care could be incorporated into routine nursing practice. Further study is needed and expected to solve more clinical problems.</td>
</tr>
</tbody>
</table>
A study by Ademuyiwa and Okubadejo (2021) compared the effect of educating stroke patients by specialist nurses at discharge and 3, 6, and 9 months postdischarge versus the usual instruction at discharge. They found that the group that was actively educated by the nurses was significantly associated with better lifestyle modification (25/30, P < 0.05), diet modification (27/30, P < 0.05), physical therapy and clinic attendance (26/30, P < 0.05), and compliance to drugs (28/30, P < 0.05) when compared to the usual care (10/30, P < 0.05), (12/30, P < 0.05), (2/30, P < 0.05), and (5/30, P < 0.05), respectively.

Another study by Kim (2012) found that the nurse-led enjoyable motor activity focusing on the plegic limb of stroke patients was associated with significant improvement in patient physical functioning after stroke in rural China. Further stroke rehabilitation research suitable for resource-poor settings is required, with several components being suggested through stakeholder interviews in our study.

**Table 1:** Continued.

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<tr>
<th>Study ID</th>
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<th>Male, n (%)</th>
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<th>Stroke types, n (%)</th>
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<th>Inclusion criteria</th>
<th>Primary endpoints</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zhou et al. 2019</td>
<td>Nurse led, 118 (47.97%)</td>
<td>China</td>
<td>RCT</td>
<td>64.3 (9.2)</td>
<td>54 (46.6%)</td>
<td>Mean (8)</td>
<td>(i) Illiterate, 32 (27.6%); (ii) Primary school, 44 (37.9%); (iii) Middle school, 32 (27.6%); (iv) Senior high school, 8 (6.9%)</td>
<td>(i) Smoker, 38 (32.8%); (ii) HTN, 85 (73.3%); (iii) DM, 15 (12.9%); (iv) CVD, 27 (23.3%)</td>
<td>Ischemic stroke, 85 (73.3%)</td>
<td>0-1, 79 (32.1%)</td>
<td>(i) Aged 18-79 years. (ii) Required assistance with ADL (score ≥60/100 on the BI). (iii) Were free of comorbid severe diseases. (iv) Able to provide consent.</td>
<td>(i) BI scores. (ii) mRS scores.</td>
<td>A novel nurse-led, digitally supported, caregiver-delivered stroke rehabilitation program did not improve patient physical functioning after stroke in rural China. Further stroke rehabilitation research suitable for resource-poor settings is required, with several components being suggested through stakeholder interviews in our study.</td>
</tr>
</tbody>
</table>

Abbreviations: ADL, activities of daily living; AF, atrial fibrillation; AIS, acute ischemic stroke; AIS-APS, acute ischemic stroke-associated pneumonia score; AM, automated monitoring; AS, acute stroke; BI, Barthel index; CAD, coronary artery disease; CHD, coronary heart disease; CVA, cerebrovascular accident; CVD, cardiovascular disease; DM, diabetes mellitus; EM, early active mobilization; HTN, hypertension; IQR, interquartile range; MBI, modified BI; MRI, magnetic resonance imaging; mRS, modified Rankin scale; NIHSS, National Institutes of Health Stroke Scale; PA, Pulmonary Artery; RCSQ, Richards–Campbell Sleep Questionnaire; RCT, randomized controlled trial; SAP, systolic arterial pressure; SSQOL, stroke-specific quality of life; TCP, transitional care program; TIA, transient ischemic attack; VHD, valvular heart disease.
when compared to the control arm regarding motor function (MD = 1.40; \( P < 0.01 \)), fatigue (MD = -9.60; \( P < 0.05 \)), sleep disturbances (MD = -3.10; \( P = 0.01 \)), and depression (MD = -1.70; \( P = 0.05 \)).

Urcan and Kolcu (2022) assessed post-stroke sleep quality and quality of life using the Richards–Campbell Sleep Questionnaire (RCSQ) (Richards, 1987) and Stroke-Specific Quality of Life (SSQOL) (Williams et al., 1999) Scale, respectively. They found that the interventional group was significantly associated with a posttest improvement in all SSQOL domains compared to the pretest state (all domains have \( P < 0.001 \)). Moreover, they found that the interventional group was significantly associated with a higher RCSQ score compared to the control arm (\( t = 2.437, P < 0.05 \)). Additionally, they found a significant improvement in the interventional group regarding the posttest RCSQ score when compared to the pretest score (\( t = -5.020, P < 0.001 \)).

Wang et al. (2022b) used the National Institutes of Health Stroke Scale (NIHSS) (Kwah and Diong, 2014) and the Mental Health Inventory-5 (Veit and Ware, 1983) to evaluate

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**Figure 3:** Forest plot of modified BI. Abbreviations: BI, Barthel index; CI, confidence interval.

**Figure 4:** Forest plot of modified BI after leaving one study out. Abbreviations: BI, Barthel index; CI, confidence interval.

**Figure 5:** Forest plot of BI. Abbreviations: BI, Barthel index; CI, confidence interval.

**Figure 6:** Forest plot of mRS \( \leq 2 \). Abbreviations: CI, confidence interval; mRS, modified Rankin scale.
disability and mental health status, respectively. They found that a nurse-led program was associated with an overall improvement in disabilities. The number of patients who scored NIHSS 1-4 and were managed by the nurse-led program was significantly higher than the usual care (27 (50%) vs 16 (28.6%), \( P < 0.001 \)). Additionally, the proportion of patients who scored NIHSS 5-12 was lower in the nurse-led programs when compared to the usual care (13 (24.1%) vs 29 (51.8%), \( P < 0.001 \)). However, they found that the group with better mental health was associated with a lower NIHSS score, which could be confounding to the lower disability state of the nurse-led program.

**DISCUSSION**

This SR and MA pooled data from 16 eligible studies. We found that the nurse-led rehabilitation programs were significantly associated with a higher BI and modified BI scores in addition to a lower proportion of patients with mRS >2. This yielded a significant overall motor improvement in the groups managed by the nurse-led programs compared to the usual care. However, no significant difference was found between the groups organized by the nurse-led programs compared to the usual care regarding the EQ-5D and the proportion of patients who scored \( \leq 2 \) in the mRS.
The included studies varied tremendously in the complete study timeframe of rehabilitation and follow-up in around a month (Kim, 2012; Ai et al., 2022; Wang et al., 2022a; Zheng et al., 2023), up to 3 months (Langhorne et al., 2010; Yue et al., 2013; Wong and Yeung, 2015; Li et al., 2021; Wang et al., 2021; Cha et al., 2022; Deng et al., 2022), or up to 9 months (McAlister et al., 2014; Zhou et al., 2019; Ademuyiwa and Okubadejo, 2021; Urcan and Kolcu, 2022; Wang et al., 2022b). However, inspecting the forest plots of the statistically significant results, the mRS >2, the BI, and the modified BI showed no correlation between the overall study timeframe and the improvement in motor disability. Additionally, the included studies differed significantly in the method of nurse-led management, from telephone follow-up to inpatient semi-supervised actual rehabilitation. However, it was inevitable for us to gather meta-analyzable data that provide preliminary correlated positive results associated with the nurse-led program.

Nurses’ roles in managing stroke patients are pivotal (Adoeye et al., 2019). They were not only capable of participating in all phases of managing post-stroke patients, including emergent care of the stroke patients within the first 24 h, acute care within the next 2 days, and post-acute follow-up and rehabilitation, but they were considered the cornerstones regarding the transitioning of the patients through these phases (Camicia et al., 2021). Thus, they have a significant opportunity to lead and coordinate approaching stroke patients among multidisciplinary teams and eliminate the lost time in reaching a medical decision (Yang et al., 2019; Green et al., 2021).

The strengths and the values that our paper added to the literature could be summarized as follows: (i) We conducted the first MA that quantifies the efficacy of nurse-led programs on the motor disability of stroke patients versus usual care. (ii) We tried to give insights that aid developing guidelines for specific rules or methods for nurses in rehabilitations. (iii) We also had a large sample size with a total of 2072 patients.

However, our study was not free of limitations, which are as follows: (i) heterogeneous studies of nursing doing different actions. As the assessed outcomes were reported in all studies, we had to do this to pool more extensive data. (ii) We did not define the nurse-led rehabilitation programs; instead, we gathered all available evidence regarding nurses’ roles in managing post-stroke patients. This yielded inter-study heterogeneity that could influence the results drawn from the outcomes measures. (iii) Additionally, the intervention group of some of the included studies compared the effect of multidisciplinary nursing versus the usual care. However, the involvement of other team members, including a professional therapist and a supervisor physician, might play a role in the superiority of the nurse-led programs versus the usual care respecting the measured outcomes. (iv) Although the relatives and caregivers of stroke patients play a significant role in managing the patients after discharge, we did not analyze the association between their roles and improvement in motor disability because of lacking data.

Thus, future high-quality randomized controlled trials (RCTs) comparing isolated nurse-led programs versus the usual care are required to draw a significant result about the isolated role of nurses.

Implication for nursing and health policy

Health policymakers and nursing faculties should consider the substantial role of nurse-led programs in improving stroke rehabilitation outcomes. The integration of such programs into the standard care protocol may not only enhance patient outcomes but also potentially mitigate the burden of stroke-related morbidity and mortality. Increased investments and capacity building in nurse-led programs could be a strategic focus for fostering recovery in post-stroke patient management.

CONCLUSION

We found that nurse-led rehabilitation programs were associated with an overall positive tendency regarding improving the disability of post-stroke patients. However, heterogeneity in the literature needs to be strictly minimized. We recommend that the nurse-led programs be clearly defined, isolated from the multidisciplinary teams, and specified in one study arm to draw significant results regarding their roles in managing post-stroke patients.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest in association with the present study.

ACKNOWLEDGMENTS

The authors extend their appreciation to the King Salman Center for Disability Research (funder ID http://dx.doi.org/10.13039/501100019345) for funding this work through Research Group no KSRG-2022-061.

ETHICAL APPROVAL

Ethical approval was not required because the data were secondary data obtained from the databases.

AUTHOR CONTRIBUTIONS

KAA, HAF, and DEF were responsible for the study conception and design and drafting of the manuscript. KAA, HAF, and DEF provided supervisions and critical revisions to the drafts.

DATA AVAILABILITY

All data analyzed in this systematic review and meta-analysis were obtained from previously published studies, and no primary data were collected.
REFERENCES


review and meta-analysis. Lancet Neurol., 8(11), 1006-1018. 10.1016/S1474-4422(09)70236-4.