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Instant message-delivered dyadic intervention in sodium reduction for hypertensive stroke survivors: A randomised controlled trial

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Abstract

High sodium intake is the primary dietary risk factor for stroke. This trial allocated 110 stroke survivor-family caregiver dyads to the intervention(sodium reduction messages plus nurse-led chat support via an instant messaging application) or control group(general stroke-education messages). Stroke survivors showed significant improvements in knowledge, attitude, and practice regarding sodium reduction(KAP) at post-intervention(T1) (β=10.44, 95% confidence interval[CI] 5.22 to 15.66, d=0.75) and 2-month follow-up(T2) (β=9.20, 95% CI 3.70 to 14.70, d=0.71), systolic blood pressure(SBP) at T1 (β=−6.19, 95% CI −9.92 to −2.47, d=−0.64) and T2 (β=−4.15, 95% CI −8.13 to −0.18, d=−0.42), diastolic blood pressure(DBP) at T1 (β=−3.65, 95% CI −6.64 to −0.66, d=−0.49), self-efficacy at T1, and dyadic relationship at T2. Family caregivers showed improved KAP at both time points and self-efficacy at T1 without increasing caregiving burden. The intervention was an effective and scalable approach to improve sodium reduction-related outcomes and BP control in stroke survivors with hypertension.

INTRODUCTION

Stroke, characterised by high morbidity, disability, mortality, and recurrence rates, is a major non-communicable disease posing significant burdens on public health. According to the 2023 Global Burden of Diseases Study, stroke was the second leading cause of mortality and the third leading cause of disability globally, responsible for 6.8 million deaths and 156 million disability-adjusted life years (DALYs)[1]. Overall, 83% of the stroke burden is attributable to modifiable risk factors, among which hypertension (HTN) and high sodium intake are particularly prominent[1]. HTN, the most prevalent modifiable risk factor contributing to stroke-related DALYs, accounted for 57.9% of total stroke-related DALYs[1]. Critically, high sodium intake contributes to stroke burden largely through its effect on raising blood pressure (BP)[2]. High sodium intake ranked first among dietary risk factors contributing to stroke-related DALYs, ahead of diets high in processed meat, diets low in fruits, diets low in vegetables, and diets low in whole grains, accounting for 9.8% of total stroke-related DALYs in 2023[1]. Reducing sodium intake is well established to reduce BP and stroke risks[3]. The World Health Organization (WHO) recognises sodium intake reduction as one of the most cost-effective strategies for improving health and lowering the burden of non-communicable diseases including stroke, with an estimated return of at least USD 12 for every USD 1 invested in sodium intake reduction[4].

China is among the countries with the highest sodium intake worldwide[5]. Chinese adults consume approximately 5g sodium daily[6], more than double the WHO recommended limit of 2g per day (equivalent to 5g salt per day)[7], and an estimated 76.7-92.6% of the population exceeds this limit[6,8]. While data on sodium intake amount among stroke survivors with HTN in China remain limited, the Salt Substitute and Stroke Study (SSaSS), a large-scale cluster randomised controlled trial (RCT) involving 15,249 stroke survivors of whom 84.6% had HTN,

reported an average intake of 3.5g sodium per day (i.e., 8.8g salt per day)[9], far exceeding the WHO recommended limit. Taken together, the high prevalence of high sodium intake in the general Chinese population and the SSaSS findings suggest that most Chinese stroke survivors with HTN are likely consuming sodium well above the WHO recommended limit[9]. Importantly, unlike Western countries where processed foods are the primary source of sodium intake, 70%–80% of sodium intake in China derives from salt added during home cooking, giving individuals in China greater personal control over their discretionary salt use at home cooking than populations reliant on processed foods as their main sodium intake source[6,10,11]. In alignment with the WHO's SHAKE technical package for sodium intake reduction, behavioural interventions are therefore well-suited to reducing sodium intake among stroke survivors with HTN in China[12].

Despite this potential, trials targeting sodium intake reduction through behavioural interventions in stroke survivors remain notably limited[13]. According to Social Cognitive Theory (SCT), knowledge of the health consequences of high sodium intake is a fundamental precondition for dietary behaviour change[14]. Without understanding high sodium intake elevates BP and increases recurrent stroke risks, stroke survivors with HTN have little motivation to endure the difficulty of reducing their consumption of high-sodium foods. Furthermore, outcome expectancies, an individual's attitudes about the consequences of sodium take reduction practices, play a critical role in shaping behaviour[14]. These expectancies encompass anticipated positive outcomes such as reduced BP and lower recurrent stroke risks, alongside potential negative concerns such as diminished taste satisfaction and reduced meal enjoyment[15]. The interplay between positive and negative outcome expectancies influences stroke survivors' willingness to adopt and maintain sodium intake reduction practices. In China, high sodium intake among stroke survivors with HTN is accompanied by substantial

knowledge, attitude, and practice (KAP) gaps: 65.7% of stroke survivors were unaware that high sodium intake increases stroke risks, 48.7% were unaware of its impact on BP, and although 64.4% reported attempting sodium intake reduction, their actual intake remained persistently high[9]. Following SCT's theoretical pathway, behavioural interventions that improve KAP regarding sodium intake reduction can subsequently facilitate BP control and lower stroke risks[16,17].

Meta-analyses of behavioural interventions for sodium intake reduction have identified several intervention design characteristics that are promising in China's context, including a focus on patient-family dyads (effect size g=0.50), delivery via instant messages (g=0.53), and nurse-led implementation (g=0.31)[13,18]. Approximately 80% of stroke survivors in China are cared for at home by family caregivers[19], who often play a critical role in dietary management, particularly for survivors whose post-stroke physical, cognitive, or psychological impairments limit their independence in managing their diet[20]. Through meal preparation, grocery shopping, and home cooking, family caregivers can substantially influence the sodium intake of stroke survivors[21]. The wide reach and cost-effectiveness of mobile health (mHealth) have made it an increasingly popular modality for delivering sodium intake reduction interventions[22]. Among those mHealth approaches, instant messaging is a particularly compelling modality for behavioural interventions targeting to sodium intake reduction (g=0.53)[13]. In China, WeChat, the dominant instant messaging application (App), has strong penetration among older adults, with users aged 55 and above, the demographic most affected by stroke[23], exceeding 61 million and continuing to grow steadily[24]. Unlike dedicated health-related applications, which require additional learning and often suffer from low adoption, WeChat leverages the mobile communication infrastructure already embedded in users' daily routines, while offering free access, personalised multimedia content delivery, and real-time bidirectional interactions,

making it a highly accessible and scalable channel for delivering behavioural interventions to stroke survivors with HTN in China. Interventions involving healthcare professionals are also more effective in reducing sodium intake than self-guided approaches[25]. Nurses are well-positioned to deliver sodium intake reduction strategies including education, skills building, and personalised feedback to patients and their caregivers[18], and integrating nurse-led support with instant messaging technologies can combine clinical expertise with the scalability and accessibility of digital delivery. However, no existing trial has combined nurse-led, instant message-delivered, and dyadic approaches to sodium intake reduction in this population. Thus, this RCT, underpinned by SCT, aimed to evaluate the effectiveness of a nurse-led, instant message-delivered dyadic intervention on KAP regarding sodium intake reduction, BP, self-efficacy of post-stroke management, quality of life (QoL), and dyadic relationship among stroke survivors with HTN; and on KAP regarding sodium intake reduction, general self-efficacy, dyadic relationship, and caregiver burden among family caregivers.

RESULTS

Baseline Characteristics of Stroke Survivor and Family Caregiver Dyads

A total of 1,350 patients were screened for eligibility from November 2024 to March 2025. Of these, 110 stroke survivors with HTN and 110 family caregivers (N=110 dyads) were enrolled and randomly assigned to the intervention group (n=55 dyads) and control group (n=55 dyads). The CONSORT flow chart is presented in Figure 1. The total dropout rates were 10.9% (12 dyads) at T1 (post-intervention) and 19.1% (21 dyads) at T2 (2-month follow-up). Comparisons between complete and dropout cases in stroke survivors and family caregivers are shown in Supplementary Table 1 and Supplementary Table 2, respectively.

For stroke survivors with HTN, the mean age was 64.81 years (standard deviation [SD]=10.25). The majority were male (68.18%), married (84.55%), and retired (71.82%), with most of them living with their families (95.45%). Ischaemic stroke was the predominant stroke type (94.55%), and the most prevalent comorbidities were diabetes mellitus [DM] (47.27%) and dyslipidaemia (42.73%). The median total KAP score was 24.00 (Interquartile Range [IQR] 17.25 to 33.00). The baseline mean systolic BP (SBP) was 136.24 mmHg (SD=13.36) and mean diastolic BP (DBP) was 83.77 mmHg (SD=10.70). Self-rated proficiency in using WeChat (e.g., reading and sending instant messages) had a median of 4.00 out of 5.00 (IQR 3.00 to 4.00). No statistically significant differences were found between groups in the sociodemographic characteristics or outcome variables at baseline among stroke survivors (Table 1).

For family caregivers, the mean age was 51.37 years (SD=14.82), and the majority were female (63.64%). Nearly half were spouses or partners of the stroke survivor (46.36%), followed by children (39.09%). The mean total KAP score was 36.26 (SD=11.16), and self-rated proficiency in reading and sending WeChat messages had a median of 4.00 (IQR 4.00 to 5.00). Similarly, no statistically significant between-group differences were observed in any sociodemographic characteristics or outcome variables at baseline for family caregivers, except for the frequency of eating lunch at home (Table 2).

The Intervention Effects on Stroke Survivors

KAP regarding sodium intake reduction: The intervention significantly improved total KAP score regarding sodium intake reduction in stroke survivors at T1 (group×time interaction coefficient [β]=10.44, 95% Confidence Interval [CI] 5.22 to 15.66, $p<0.001$, Cohen's d=0.75) and at T2 (β=9.20, 95%CI 3.70 to 14.70, $p<0.001$, Cohen's d=0.71) (Table 3 and

Supplementary Figure 1.1). Significant improvements were also observed across all three subscales at both time points, with effect sizes ranging from 0.48 to 0.67 (Supplementary Figure 1.2-1.4).

SBP and DBP: The intervention led to a statistically significant reduction in SBP among stroke survivors at both T1 (β=-6.19, 95%CI -9.92 to -2.47, p<0.001, Cohen's d=-0.64) and T2 (β=-4.15, 95%CI -8.13 to -0.18, p=0.04, Cohen's d=-0.42) (Table 3 and Supplementary Figure 2.1). DBP was also significantly lowered at T1 (β=-3.65, 95%CI -6.64 to -0.66, p=0.02, Cohen's d=-0.49) (Table 3 and Supplementary Figure 2.2). However, this reduction was no longer statistically significant at T2 (β=-1.58, 95%CI -4.76 to 1.60, p=0.33, Cohen's d=-0.20). For SBP, observed power was 0.91 at T1 and 0.61 at T2. For DBP, observed power was 0.67 at T1 and 0.18 at T2.

Self-efficacy: The intervention significantly enhanced self-efficacy of post-stroke management in stroke survivors at T1 (β=9.15, 95%CI 0.26 to18.03, p=0.04, Cohen's d=0.39) (Table 3 and Supplementary Figure 3). However, this improvement was not sustained at T2 (β=6.67, 95%CI -2.45 to 15.80, p=0.15, Cohen's d=0.29).

Quality of life (QoL): The intervention did not have a significant effect on QoL (the EQ-5D-3L index) in stroke survivors at T1 (β=0.05, 95%CI -0.03 to 0.14, p=0.22, Cohen's d=0.24) and at T2 (β=0.05, 95%CI -0.05 to 0.15, p=0.31, Cohen's d=0.20) (Table 3 and Supplementary Figure 4.1). Similarly, no significant change was observed in the EQ-5D-3L-VAS score at T1 (β=2.07, 95%CI -3.01, 7.15, p=0.43, Cohen's d=0.16) or at T2 (β=1.89, 95%CI -3.08 to 6.86, p=0.46, Cohen's d=0.15) (Table 3 and Supplementary Figure 4.2).

Dyadic relationship (DR): The intervention showed a trend toward improved DR in stroke survivors at T1, though this did not reach statistical significance (β=-1.41, 95%CI -2.89 to 0.06, p=0.06, Cohen's d=-0.37). By T2, the improvement became statistically significant (β=-1.66, 95%CI -3.30 to -0.03, p=0.047, Cohen's d=-0.41) (Table 3 and Supplementary Figure 5).

The Intervention Effects on Family Caregivers

KAP regarding sodium intake reduction: The intervention also significantly improved total KAP score regarding sodium intake reduction in family caregivers at T1 (β=7.75, 95%CI 3.29 to 12.22, p<0.001, Cohen's d=0.68) and at T2 (β=6.35, 95%CI 2.16 to 10.55, p<0.001, Cohen's d=0.60) (Table 4 and Supplementary Figure 6.1). Among the subscales, the intervention significantly improved practice (KAP-P) at both time points, whereas improvements in knowledge (KAP-K) and attitude (KAP-A) did not reach statistical significance at either time point (Supplementary Figures 6.2–6.4).

Self-efficacy: The intervention significantly enhanced general self-efficacy among family caregivers at T1 (β=2.32, 95%CI 0.06 to 4.58, p=0.04, Cohen's d=0.40) (Table 4 and Supplementary Figure 7). However, this effect was not maintained at T2 (β=0.89, 95%CI -1.44 to 3.21, p=0.46, Cohen's d=0.15).

DR: The intervention did not significantly improve DR in family caregivers at either T1 (β=-1.26, 95%CI -2.79 to 0.28, p=0.11, Cohen's d=-0.32) or at T2 (β=-0.89, 95%CI -2.57, 0.79, p=0.30, Cohen's d=-0.22) (Table 4 and Supplementary Figure 8).

Caregiver burden: Despite incorporating family caregivers into the dyadic intervention, caregiver burden did not significantly increase at T1 (β=-0.93, 95%CI -2.16 to 0.30, p=0.14,

Cohen's d=-0.29) or at T2 (β=-0.38, 95%CI -1.57 to 0.80, p=0.53, Cohen's d=-0.13) (Table 4 and Supplementary Figure 9).

Sensitivity Analysis on the Effects in Stroke Survivors and Family Caregivers

Sensitivity analyses using both generalised estimating equations (GEE) with multiple imputation under the intention-to-treat (ITT) principle and complete-case analyses confirmed the robustness of the findings. Specifically, significant intervention effects remained consistent across both analytical approaches for stroke survivors in all KAP measures (KAP-K, KAP-A, KAP-P, and KAP-Total scores) at T1 and T2, SBP at T1 and T2, DBP at T1, self-efficacy at T1, and DR at T2, as well as for family caregivers in KAP-Total and KAP-P scores at T1 and T2, and self-efficacy at T1 (Supplementary Table 3 and Supplementary Table 4).

Perceived Intervention Satisfaction and Usefulness

Both stroke survivors and family caregivers in the intervention group perceived the intervention as highly satisfactory and useful throughout the study period. Among stroke survivors, satisfaction (median=5.00, IQR 4.00 to 5.00) and usefulness ratings (median=5.00, IQR 4.00 to 5.00) were high at T1 and remained so at T2 (satisfaction: median=4.00, IQR 4.00 to 5.00; usefulness: median=5.00, IQR 4.00 to 5.00). Similarly, family caregivers reported high satisfaction (median=5.00, IQR 4.00 to 5.00) and usefulness (median=5.00, IQR 4.00 to 5.00) at T1, which were maintained at T2 (satisfaction: median=4.00, IQR 4.00 to 5.00; usefulness: median=5.00, IQR 4.00 to 5.00).

DISCUSSION

Despite consistent recommendations from the WHO and stroke guidelines advocating sodium intake reduction as a key secondary stroke prevention strategy for lowering BP and minimising

recurrent stroke risk, high sodium intake remains prevalent among stroke survivors with HTN in China[9]. This study was the first to design and evaluate a nurse-led, theory-driven dyadic behavioural intervention delivered via instant messaging, targeting KAP improvement regarding sodium intake reduction among stroke survivors with HTN worldwide, including in China. The intervention produced significant and medium-to-large effects on KAP regarding sodium intake reduction (Cohen's d=0.71–0.75), as well as significant effects on BP reduction (Cohen's d=0.42–0.64), self-efficacy (Cohen's d=0.39), and DR (Cohen's d=−0.41) among stroke survivors with HTN. Notably, the dyadic approach also conferred benefits to family caregivers' KAP regarding sodium intake reduction and self-efficacy without imposing additional caregiver burden. The significant improvements in KAP regarding sodium intake reduction, BP control, self-efficacy, and DR can be attributed to the intervention's structured design, which aligned SCT pathways and mapped with evidence-based behaviour change techniques (BCTs). The intervention first addressed knowledge gaps regarding the associations between high sodium intake, BP, and stroke recurrence[9]. Given that the majority of Chinese individuals consume excessive sodium and underestimate their intake[15], this educational content also facilitated attitude modification by dispelling common misconceptions among this population, such as the beliefs that sodium intake reduction diminishes physical strength, that long-standing dietary habits cannot be changed, or that low-sodium food lacks palatability[14]. The intervention subsequently provided practical skills for reducing sodium intake from three sources: cooking salt and condiments, processed foods, and out-of-home meals. To enhance post-stroke management self-efficacy, each skill was illustrated through text and images alongside actionable behavioural goals and personalised action plans (using BCTs such as 'goal-setting [behaviour]'), which collectively bolstered participants' self-efficacy for reducing sodium intake[26]. Finally, regular WeChat messages were delivered within a three-member group chat comprising the stroke survivor, family caregiver, and nurse interventionist,

positioning both nurses and family caregivers as social facilitators to reinforce self-efficacy and sustain behaviour change, leading to BP reduction[14]. Taken together, these significant improvements in KAP regarding sodium intake reduction, BP control, self-efficacy, and DR underscore the instant message-delivered intervention's potential as a viable approach to secondary stroke prevention.

For primary outcome, the improvements in KAP regarding sodium intake reduction were consistent with, yet larger in effect sizes than, those reported in previous family-involved sodium intake reduction interventions in China, including a mobile App-based intervention among schoolchildren and their families and a home cook-led intervention among families[27,28]. Several factors may account for these enhanced effects. First, stroke survivors may possess heightened health motivation following their stroke events, as this population often demonstrates increased receptiveness to lifestyle modifications after experiencing an acute cardiovascular event (a teachable moment)[29]. Second, the use of WeChat as the delivery platform, rather than a specially designed App, would reduce usage barriers for this older population (mean age 64.81 years, who reported high WeChat proficiency at baseline (median 4.00 out of 5.00), thereby facilitating greater engagement[13]. Third, the combination of regular instant message delivery with personalised nurse-led real-time chat support, alongside ongoing social support from both family caregiver and the nurse, may have further strengthened KAP outcomes by balancing scalability with tailored care[30,31].

For secondary outcomes, first, the intervention significantly reduced SBP at both T1 (β=-6.19 mmHg, Cohen's d=-0.64) and T2 (β=-4.15 mmHg, Cohen's d=-0.42), and DBP at T1 (β=-3.65 mmHg, Cohen's d=-0.49). The SBP reduction at T1 was clinically meaningful, as a 5 mmHg decrease in SBP has been reported to lower stroke risks by 13% and CVD-related deaths by

5%[32], and every 10 mmHg reduction could reduce stroke risks by 27%[33]. The greater reduction in SBP than DBP was consistent with meta-analytic evidence that SBP responds more robustly to sodium intake reduction than DBP[34]. These BP reductions were notably larger than those reported in other family-involved sodium intake reduction interventions in China, such as SBP/DBP reductions of 2.0/1.1 mmHg in a home cooking intervention[28] and SBP reductions of 2.05 mmHg among stroke survivors in the SSaSS study[9]. The enhanced effects may be explained by stroke survivors' heightened motivation following their stroke compared with the general population, the comprehensive coverage of three sodium intake sources rather than home cooking alone[28,35], and the nurse-led personalised guidance combined with consistent home BP measurement (HBPM) reminder compared with studies without tailored support[36]. The non-significant DBP reduction at T2 may be attributed to the high proportion of males in this sample, as SBP reductions are more pronounced in males whilst DBP reductions are more pronounced in females[37]. Additionally, the absence of continuous nurse-led reminders during the follow-up period may have reduced adherence to sodium reduction behaviours, further attenuating the DBP reduction at T2. Second, the improvement in self-efficacy was consistent with a meta-analysis showing that dyadic interventions significantly improved self-efficacy post-intervention[38]. This enhancement, a critical mechanism for behaviour change[14], was attributable to the intervention's systematic targeting of four self-efficacy sources: mastery experience through practising specific sodium intake reduction skills with small actionable goals[39,40]; vicarious experience through skill demonstrations via texts, images, and videos[41,42]; verbal persuasion through nurse-delivered encouragement and reassurance that sodium intake reduction was achievable without compromising palatability[26,43]; and management of emotional arousal through nurse-led real-time chat support and promoting family caregivers' emotional support and dyadic coping strategies[43]. However, no significant intervention effects were observed on QoL. This was likely attributable to two factors: first, the intervention's

specific focus on sodium intake reduction may have been insufficient to influence this broad, multidimensional construct shaped by physical, cognitive, and emotional post-stroke impairments[44]; second, the relatively short follow-up period may have been inadequate to capture meaningful changes in QoL. Future studies may benefit from multi-component approaches addressing these diverse domains, with longer follow-up periods to detect potential delayed effects on QoL among stroke survivors.

This study had methodological strengths. First, the intervention was grounded in SCT and systematically integrated evidence-based BCTs throughout all modules, providing a coherent theoretical framework for changing behaviour and exploring mechanisms. This theory-driven approach also offers a replicable design template for future behavioural intervention development, facilitating their reproducibility and scalability. Second, the intervention utilised instant messaging technology (i.e., WeChat) as the delivery platform, which is low-cost or even free of charge, responding to the WHO's call for scalable interventions and offering high accessibility for stroke survivors, while the dyadic approach that actively involved family caregivers was culturally congruent with post-stroke family care[21]. However, this study had several limitations. First, the overall dropout rate at T2 was 19.1%, with dropouts being older, more likely female, and having poorer functional independence and lower WeChat proficiency, suggesting the intervention may be less feasible for more vulnerable stroke survivors and limiting generalisability. Second, the study relied on self-reported measures susceptible to recall bias and Hawthorne effect; future studies could consider objective measures such as 24-hour urinary sodium (24HUNa) to corroborate findings, resources permitting. Third, although the 2-month follow-up period was adequate for examining effects based on existing evidence, future studies could adopt a longer follow-up to examine the sustainability of intervention effects.

The findings of this study had significant practical implications. Globally, high sodium intake was responsible for 3 million global deaths in 2017[5]. Despite the WHO's goal of achieving a 30% reduction in mean population sodium consumption by 2025[4], this target remains unmet: only 5% of the 194 Member States had implemented mandatory and comprehensive sodium intake reduction policies, while 73% had not fully implemented such policies, underscoring the persistent gap between commitment and action in global sodium intake reduction efforts. This study contributes to this ongoing agenda by providing evidence for a scalable, nurse-led, instant messaged-delivered intervention to improve KAP regarding sodium intake reduction among stroke survivors. As nurses constitute the largest segment of the healthcare workforce, leveraging their clinical expertise alongside widely accessible platforms such as WeChat or WhatsApp offers a pragmatic and adaptable solution. The intervention could be culturally adapted to other contexts, including regions where home cooking represents the primary source of sodium intake, other sub-populations, or the general population, by following the theoretical framework, BCTs mapping process, and intervention development steps demonstrated in this study while tailoring content to local dietary habits and prevalent instant messaging Apps. Furthermore, the dyadic approach actively involved family caregivers in lifestyle modification, potentially enhancing the sustainability of behaviour change at the household level, suggesting that future sodium intake reduction initiatives could benefit from embedding family-based strategies into routine community health services.

In conclusion, a nurse-led, instant message-delivered dyadic behavioual intervention was effective for improving KAP regarding sodium intake reduction, lowering BP, improving post stroke management self-efficacy and DR among stroke survivors with HTN in China. The intervention also benefited family caregivers by enhancing their KAP regarding sodium intake

reduction and self-efficacy without increasing their caregiving burden. This study provided evidence supporting instant messaging as a scalable and widely accessible digital health modality for delivering behavioural interventions in sodium intake reduction, with particular relevance to settings where home cooking is the primary source of sodium intake.

METHODS

Study design, setting, and ethical approval

This was a single-site, single-blind, two-arm parallel RCT, conducting at the Neurology Department, Guangzhou First People's Hospital, Guangzhou, China. Ethical approval was obtained from the University of Hong Kong (Ref. No.: UW 23-453) and Guangzhou First People's Hospital (Ref. No.: K-2024-044-02). This RCT was pre-registered at the Chinese Clinical Trial Registry (Registration No.: ChiCTR2400086708) on 09 July 2024. The full study protocol has been published previously[45]. This study was reported following the CONSORT 2025 Statement (see the CONSORT 2025 checklist[46] and the TIDieR-telehealth [Template for Intervention Description and Replication) checklist[47] in Supplementary Checlikst 1_CONSORT 2025 and Supplementary Checlikst 2_TIDieR-telehealth, respectively).

Participant eligibility

This trial focused on dyads consisting of the stroke survivor and one family caregiver.

Inclusion criteria of stroke survivors*:* 1) community-dwelling adults aged ≥ 18 years; 2) diagnosis of stroke; 3) diagnosis of HTN regardless of taking antihypertensive medications[8]; 4) ability to read and communicate in Chinese including Mandarin or Cantonese at a functional level; 5) ability to use instant messaging applications, such as reading and sending WeChat messages; 6) able to participate in this study for 4 months; and 7) can sign the informed consent form.

Exclusion criteria of stroke survivors*:* 1) currently receiving acute stroke care in inpatient settings; 2) current participation in any dietary or HTN-related lifestyle modification interventions; 3) inability to consume food orally (e.g., reliance on nasogastric tubes or other enteral nutrition methods); or 4) presence of moderate or severe cognitive impairments or psychiatric disorders (e.g., dementia) or other conditions that preclude study participation.

Inclusion criteria of family caregivers*:* 1) adults aged ≥ 18 years that can provide unpaid care and support to the stroke survivor, such as spouse or partner, parents, children, siblings, or friends[48]; 2) ability to read and communicate in Chinese including Mandarin or Cantonese at a functional level; 3) ability to use instant messaging applications, such as reading and sending WeChat messages; 4) able to participate in this study for 4 months; and 5) can sign the informed consent form.

Exclusion criteria of family caregivers*:* 1) current participation in any dietary or HTN-related lifestyle modification interventions; or 2) presence of moderate or severe cognitive impairments or psychiatric disorders (e.g., dementia) or other conditions that preclude study participation.

Sample size

No prior trials have examined the effects of nurse-led, instant message-delivered dyadic behavioural interventions on KAP regarding sodium intake reduction among stroke survivors with HTN. Given the absence of directly comparable evidence, the sample size estimation for this RCT drew on two similar sources. First, baseline variability in KAP score was informed by a large cross-sectional study conducted across six provinces in China, which surveyed 5,453 adults aged 18–75 years. Among participants with HTN, the mean KAP score for sodium intake reduction was 30.32 (SD=8.40) out of a possible 60 points[16]. These values provided the baseline estimates of variability in KAP score for the sample size calculation. Second, the anticipated intervention effect was estimated from a prior mobile application-based sodium reduction intervention targeting schoolchildren and their families in China. That study reported a mean between-group difference of 0.81 points on an adapted 10-point KAP scale, yielding a Cohen's d of 0.60. Scaling this effect to the 60-point KAP instrument used in the current RCT corresponded to an expected mean difference of approximately 5 points[27]. Thus, based on the

anticipated effect size of 0.60, the sample size calculation assumed a mean difference of 5 points in KAP score, a significance level (α) of 0.05, and a power (1-β) of 0.80. The formula for comparing two independent means was applied to calculate the initial sample size. With an estimated SD of 8.4 and an expected mean difference of 5 points, the initial calculation using G*Power software yielded 44 stroke survivors per group (G∗Power software, version 3.1)[49]. To account for potential attrition, a 20% dropout rate was applied, consistent with a reported average attrition rate of 19.8% in a meta-analysis of dyadic dietary interventions for patients with CVD[38]. This increased the required sample to 55 stroke survivors per group, totalling 110 stroke survivors. As the study adopted a dyadic design pairing each stroke survivor with a family caregiver, 110 dyads (220 participants in total) were required.

Blocked Randomisation and Blinding

An independent researcher, who was not involved in intervention delivery or outcome assessment, generated the randomisation sequence using a computerised programme with permuted block sizes of 4, 6, and 8. The allocation sequence was concealed in sequentially numbered, opaque, sealed envelopes. After providing informed consent and completing baseline assessments, eligible dyads were randomly allocated in a 1:1 ratio to either the intervention or control group by the independent researcher. Outcome assessors were blinded to group allocation and were explicitly instructed not to seek any allocation-related information from participants. However, as this was a non-pharmacological behavioural change intervention study, the nurse (i.e., the interventionist) was required to know the group allocation in order to deliver the appropriate intervention and therefore could not be blinded. Although blinding participants was not feasible, dyads were not informed of their group allocation and both groups received instant messages from the nurse interventionist, minimising the risk of allocation awareness and potential contamination between groups.

Intervention

The intervention was developed following the UK Medical Research Council's framework for complex interventions[50]. Details of intervention development can be seen in the study protocol[45].

***Theoretical Framework and* BCTs** Grounded in SCT, the intervention design incorporated its core constructs, including knowledge, self-efficacy, outcome expectancies, social-structural facilitators and impediments, and goals[14]. Knowledge is a precondition for behaviour change; for example, participants need to understand relationship among high sodium intake, HTN and stroke risk, as well as recommended sodium intake levels[9]. Self-efficacy is an individual's belief in their ability to perform the behaviour, such as confidence in preparing lower-sodium meals at home or choosing low-sodium alternatives. Outcome expectancies refer to an individual's perceptions about the behaviour and its possible consequences, such as believing that reducing sodium intake will lower BP and stroke risks for whole family[16]. Individual's perceived social-structural factors represent the factors that either facilitate or hinder behaviour change, including availability of low-sodium products, family food preferences, or cultural norms around seasoning and salt use[21]. Finally, individuals set goals and develop action plans to achieve them, such as setting a specific daily salt use target. Self-efficacy, the central determinant of SCT, can directly influence the behaviour and indirectly affect the behaviour through interactions with other determinants (i.e., the path of influence)[30]. The conceptual model is presented in Figure 2. BCTs are the smallest, observable, and replicable 'active ingredients' for facilitating behaviour change[51]. BCTs are the specific strategies through which theoretical determinants are operationalised. Mapping BCTs to their corresponding theoretical determinants not only enhances intervention effectiveness, but also clarifies the mechanisms

through which BCTs influence behaviour change[26]. This intervention adopted BCTs from Michie's BCT Taxonomy (BCTTv1). The mapping process was grounded in mechanisms of action (MoAs) of BCTs, which explain how and why specific BCTs achieve the desired behaviour change[26]. MoAs are regarded as the theoretical determinants, which were used to guide the mapping of BCTs on sodium intake reduction to corresponding SCT constructs[26]. The detailed mapping process is in study protocol[45].

Intervention for the Intervention Group In addition to usual care of routine outpatient follow-up appointments, the intervention for the intervention group comprised two components: regular messages and nurse-led real-time chat support. Regular messages were standardised messages delivered routinely to all dyads in the intervention group, providing health education on stroke, HTN, and sodium intake reduction, along with behavioural change skills for home cooking, grocery shopping, and dining out. This component served to consistently reinforce knowledge and practical skills across all dyads[38]. Nurse-led real-time chat support complemented the regular messages by enabling personalised, real-time feedback[52]. As standardised messages alone cannot address individual needs or monitor behaviour change progress[31]. This component allowed the nurse to track each dyad's progress and provide tailored guidance. Based on materials from the WHO's SHAKE technical package for salt intake reduction[12], guidelines of sodium intake, HTN, and stroke from the WHO[7], American Heart Association[3], American Stroke Association[53], Chinese Society of Neurology[54], and Chinese Nutrition Society[55], the regular messages covered health education on stroke, HTN, and sodium intake reduction, alongside behavioural change skills targeting three sodium intake sources, including home cooking, grocery shopping, and dining out. A total of 60 brief messages were organised into six modules: (1) Introduction- programme background and orientation; (2) Sodium and Health- essential knowledge about stroke, HTN, sodium's health

impacts (e.g., health consequences and lifestyle modifications to prevent stroke recurrence, BP control goals, and HBPM steps and self-monitoring importance, sodium intake sources, recommended intake levels, salt and sodium distinctions, and common misconceptions); (3) Home Cooking Master-skills for reducing salt and condiments use in home cooking; (4) Food Shopping Expert-skills for low-sodium processed food selection; (5) Food Ordering Specialist-skills for reducing sodium intake from restaurant meals; and (6) Summary-reinforcement of key concepts to support sustained behaviour change. Based on SCT structural paths of influence, this sequential structure was informed by SCT's paths of influence, ensuring participants first acquire foundational knowledge (Module 2) before progressing to practical skills (Modules 3-5), with introductory orientation (Module 1) and maintenance reinforcement (Module 6) to support long-term adherence. The structure of the regular messages, integrating SCT and BCTs is presented in Table 5. Nurse-led real-time chat support operated in two scenarios: participant-initiated chats and nurse-initiated chats. In participant-initiated chats, when participants contacted the nurse to report progress or raise difficulties during the intervention, they received motivational or tailored messages addressing their specific needs within 24 hours. In nurse-initiated chats, the nurse proactively reached out to prompt goal-setting, monitor behaviour change progress, identify facilitators and barriers to sodium intake reduction, or request HBPM readings. If participants did not respond to a nurse-initiated enquiry within 24 hours, a motivational message reinforcing the desired behaviour was sent to conclude the conversation. The chat support protocol is presented in Figure 3.

Intervention for the Control Group In addition to usual care, dyads in the control group received 10 brief regular messages focusing on stroke diagnosis and acute treatment education via WeChat (active control) based on materials same as the intervention group[54]. Unlike the intervention group, which received health education emphasising the relationship among stroke,

HTN, and high sodium intake, the control group received health education primarily covering stroke definition, symptoms, categories, clinical tests, medication and surgical treatments, HTN definition, and general information about sodium intake reduction for BP control and recurrent stroke prevention. Notably, the sodium intake reduction information provided to the control group did not include recommended intake levels, practical skills, or guidance on applying these skills (e.g., goal-setting and action planning). The control group did not receive nurse-initiated personalised real-time chat support, except for reminders about HBPM. When participants in the control group initiated contact with the nurse, the nurse responded briefly using neutral language to maintain follow-up rates and minimise attrition, distinct from the detailed, motivational responses provided to the intervention group.

Intervention Delivery The intervention and follow-up periods each lasted two months, as these durations have been shown to be effective in a meta-analysis of technology-supported sodium intake reduction interventions[13]. The interventionist delivered the intervention to each dyad individually through a three-member WeChat group comprising the two dyad members and the interventionist. The frequency and timing of regular message delivery were adjustable based on stroke survivors' or family members' preferences, which were assessed at baseline and could be modified during the intervention upon request from either dyad member. A minimum delivery frequency of once per week was maintained, consistent with the evidence from a related meta-analysis[13]. The nurse-led real-time chat support was offered either individually, where the stroke survivor or family member could privately message the interventionist, or within the group chat setting. The frequency of nurse-led real-time chat support was flexible and dependent on participant engagement.

Data Collection and Outcome Assessment

The primary outcome was the difference in stroke survivors' KAP regarding sodium intake reduction between baseline (T0) and immediately post-intervention (T1: 2 months after baseline). Secondary outcomes included stroke survivors' KAP at T2 (2 months follow-up), as well as SBP, DBP, self-efficacy, QoL, and DR at T1 and T2. Family caregivers' KAP, self-efficacy, DR, and caregiving burden at T1 and T2 were also assessed as secondary outcomes. Intervention satisfaction and usefulness for both dyad members in the intervention group at T1 and T2 were also assessed and treated as secondary outcomes. Detailed data collection procedures are outlined in Table 6.

KAP regarding sodium intake reduction was measured using a validated 12-item questionnaire developed through three rounds of expert consultations and pilot tested among Chinese populations[56]. The questionnaire comprised three sections: knowledge (3 items, 0–15 points), attitude (3 items, 0–15 points), and practice (6 items, 0–30 points), yielding a total score of 0–60. Higher scores indicated better sodium intake reduction KAP. Within SCT, knowledge is regarded as a fundamental prerequisite for behaviour change, while outcome expectancies (i.e., attitude) represent individuals' evaluative beliefs about a behaviour and its likely consequences[14]. Thus, focusing on KAP improvement provides a practical and theoretically grounded proxy for assessing sodium intake reduction. Higher KAP score regarding sodium intake reduction are associated with lower 24HUNa[16] and greater BP reductions[57], suggesting that improvements in KAP are meaningfully linked to both objective sodium intake and clinical outcomes.

SBP and ***DBP*** were measured using HBPM, self-reported by stroke survivors. Instructions on correct HBPM steps, adopted from the AHA HTN guideline[3], were provided to the dyad via regular messages. Stroke survivors took two measurements 1-2 minutes apart after at least 5

minutes of seated rest, with the upper arm positioned at heart level. If readings differed by more than 10 mmHg, a third measurement was taken. The average was recorded. To enhance data validity, participants uploaded photographs of device readings via WeChat, and a blinded research assistant cross-checked implausible values against the original images.

Self-efficacy for stroke survivors' post-stroke management was measured using the simplified Chinese version of the Stroke Self-Efficacy Questionnaire (SSEQ; Cronbach's α=0.70)[58], comprising 11 items rated on an 11-point Likert scale (total score 0–110). For family caregivers, general self-efficacy was measured using the simplified Chinese version of the General Self-Efficacy Scale (GSE; Cronbach's α=0.91)[59], comprising 10 items (total score 10–40). Higher scores indicated greater self-efficacy for both scales.

QoL was assessed using the simplified Chinese version of the EQ-5D-3L[60], comprising a descriptive system evaluating five dimensions (mobility, self-care, usual activities, pain/discomfort, and anxiety/depression) across three severity levels, and a visual analogue scale (VAS, 0–100). The EQ-5D-3L index was calculated using China's specific value set. Higher scores indicated better QoL.

DR was measured using the simplified Chinese version of the Dyadic Relationship Scale (DRS)[61], with separate versions for patients (Cronbach's α=0.82) and caregivers (Cronbach's α=0.83). Responses were rated on a four-point Likert scale (0–3). Higher scores indicated poorer dyadic relationships.

Caregiver burden was measured using the simplified Chinese version of the four-item Zarit Burden Interview (ZBI-4, Cronbach's α=0.887)[62], adapted from the 22-item Chinese ZBI.

Items were rated on a 5-point Likert scale (0–4). Higher scores indicated greater caregiving burden.

Intervention satisfaction and usefulness were each assessed using a single self-designed item rated on a 5-point Likert scale (1–5) for both dyad members in the intervention group at T1 and T2. Higher scores indicated greater satisfaction or perceived usefulness.

Demographic, health, dietary data, and message receiving preference were collected for both dyad members. For stroke survivors, demographic and health data included age, gender, education level, marital status, employment status, residence area, monthly household income, and perceived financial status, whether living alone, and perceived dyadic typology[63], stroke history (onset, recurrence, type), activities of living [ADL] (modified Barthel Index; Cronbach's α=0.93)[64], HTN diagnosis date, antihypertensive medication use, medication adherence (8-item Morisky Medication Adherence Scale [MMAS-8]; Cronbach's α=0.74)[65], height, weight, comorbidities, smoking, alcohol consumption, physical activity, and depression and anxiety (Patient Health Questionnaire-4 [PHQ-4]; Cronbach's α=0.83)[66]. For family caregivers, demographic and health data included age, gender, education, marital status, employment, relationship with the stroke survivor, cohabitation status, perceived dyadic typology, diagnosed diseases, and depression and anxiety (PHQ-4). Dietary data captured broader eating patterns for both dyad members, including frequency of home dining, use of sodium reduction strategies (e.g., salt restriction spoons, low-sodium condiments, checking nutrition labels), goal commitment for sodium intake reduction (the Goal Commitment Scale [GCS]; Cronbach's α=0.74)[67], prior sodium intake reduction education, and perceived social-environmental factors affecting sodium intake reduction (8-item self-designed 5-point Likert questionnaire). Higher scores in social-environmental factors indicated fewer perceived

barriers. Message receiving preference data, including preferred format, timing, and frequency, were collected from both dyad members to tailor intervention delivery.

Statistical Analysis

Continuous variables were assessed for normality with the Shapiro-Wilk test, with $p > 0.05$ indicating the data was normally distributed[68]. Categorical variables are summarised as frequencies and proportions, and continuous variables as means with SDs or medians with interquartile ranges (IQR), depending on their distribution. Baseline characteristics were compared between groups using the Chi-square test or Fisher's exact test for categorical variables, and the independent t-test or Mann-Whitney U-test for continuous variables. The ITT approach was adopted by analysing all participants according to their initial group allocation, regardless of compliance or dropout. Missing outcome data were handled directly using GEE under the Missing Completely at Random (MCAR) or Missing At Random (MAR) assumption with imputation method being weighted predictive mean matching[69], while multiple imputation with 30 imputed datasets was conducted to address missing baseline covariates[70,71]. Little's MCAR test was conducted to evaluate whether missing data were consistent with MCAR ($p>0.05$) and reported descriptively[72]. If the data were not MCAR ($p\leq0.05$), logistic regression models were used to assess whether missingness could be explained by observed variables, supporting the MAR assumption.

Between-group differences in KAP, SBP, DBP, self-efficacy, QoL, caregiving burden, and dyadic relationship across all evaluative time points were analysed using GEE. The prespecified primary analysis estimated the group × time interaction for stroke survivors' total sodium intake reduction KAP score. The group × time interaction coefficients from the GEE models were used as the main effect estimates with a Gaussian distribution, an identity link, a

first-order autoregressive working correlation structure, and model estimates used robust standard errors. All GEE models adjusted for the corresponding baseline outcome values as covariates, along with age, sex, education level, marital status, employment, and perceived dyadic typology[16]. For SBP and DBP models, antihypertensive medication use was additionally included as a covariate[73,74]. Baseline characteristics with significant between-group differences were also included as covariates. Effect sizes were quantified using Cohen's d based on adjusted mean change from baseline to assess the magnitude of intervention effects, with values of 0.2, 0.5, and 0.8 representing small, medium, and large effects, respectively[75]. Sensitivity analyses were conducted to assess the robustness of the findings by comparing results from GEE using multiple imputation with those from complete-case analysis excluding participants with missing outcomes. Post-hoc power for BP was calculated for the group × time interaction from the covariate-adjusted GEE, using the observed Cohen's d, the achieved sample size, and a two-sided α of 0.05. All analyses were two-sided, and $p<0.05$ was regarded as statistically significant. The data analysis was performed using R Studio (Version 2024.12.1+563).

Data availability

The datasets generated and analysed during this study are not publicly available due to participant privacy and ethical restrictions.

Code availability

Not applicable.

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Author contributions

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Competing Interests

The authors declared no competing interest.

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Table 1. Baseline Characteristics of Stroke Survivors (n=110)

Variables	Intervention group (n=55)	Control group (n=55)	All (N=110)	Between group p-value
Age (years), mean (SD)	64.71 (9.46)	64.91 (11.08)	64.81 (10.25)	0.92
Sex, n (%)				0.41
Female	20 (36.36)	15 (27.27)	35 (31.82)	
Male	35 (63.64)	40 (72.73)	75 (68.18)	
Education Level, n (%)				0.07
No formal education	0 (0)	3 (5.45)	3 (2.73)	
Primary school	15 (27.27)	8 (14.55)	23 (20.91)	
Junior high school	12 (21.82)	21 (38.18)	33 (30.00)	
Senior high school	20 (36.36)	14 (25.45)	34 (30.91)	
Undergraduate	8 (14.55)	9 (16.36)	17 (15.45)	
Marital Status, n (%)				0.70
Divorced	1 (1.82)	3 (5.45)	4 (3.64)	
Married	48 (87.27)	45 (81.82)	93 (84.55)	
Single	1 (1.82)	2 (3.64)	3 (2.73)	
Widowed	5 (9.09)	5 (9.09)	10 (9.09)	
Employment Status, n (%)				0.74
Full-time	7 (12.73)	8 (14.55)	15 (13.64)	
Part-time	0 (0)	1 (1.82)	1 (0.91)	
Retired	41 (74.55)	38 (69.09)	79 (71.82)	
Self–employed	2 (3.64)	4 (7.27)	6 (5.45)	
Unemployed	5 (9.09)	4 (7.27)	9 (8.18)	
Monthly Household Income (CNY), n (%)				0.68
0	5 (9.09)	5 (9.09)	10 (9.09)	
1-5,000	29 (52.73)	27 (49.09)	56 (50.91)	
5,001-10,000	15 (27.27)	16 (29.09)	31 (28.18)	
10,001-15,000	5 (9.09)	5 (9.09)	10 (9.09)	
15,001-20,000	0 (0)	2 (3.64)	2 (1.82)	
≥ 30001	1 (1.82)	0 (0)	1 (0.91)	
Perceived Financial Status, n (%)				0.30
Completely fine	4 (7.27)	1 (1.82)	5 (4.55)	
Manageable	36 (65.45)	35 (63.64)	71 (64.55)	
Not very manageable	14 (25.45)	15 (27.27)	29 (26.36)	
Tough	1 (1.82)	4 (7.27)	5 (4.55)	

Residential Area, n (%)				0.82
Rural	11 (20.00)	13 (23.64)	24 (21.82)	
Urban	44 (80.00)	42 (76.36)	86 (78.18)	
Living Alone, n (%)				1.00
No	52 (94.55)	53 (96.36)	105 (95.45)	
Yes	3 (5.45)	2 (3.64)	5 (4.55)	
Perceived Dyadic Typology, n (%)				0.73
Collaborative	9 (16.36)	6 (10.91)	15 (13.64)	
Complementary	8 (14.55)	6 (10.91)	14 (12.73)	
Family-oriented	10 (18.18)	10 (18.18)	20 (18.18)	
Patient-oriented	28 (50.91)	33 (60.00)	61 (55.45)	
Proficient in WeChat Use, median (IQR)	4.00 (3.00, 4.00)	4.00 (3.00, 4.00)	4.00 (3.00, 4.00)	0.48
Stroke Type, n (%)				0.19
IS	51 (92.73)	53 (96.36)	104 (94.55)	
HS	3 (5.45)	0 (0)	3 (2.73)	
TIA	1 (1.82)	2 (3.64)	3 (2.73)	
Recurrent Stroke, n (%)				0.46
No	43 (78.18)	47 (85.45)	90 (81.82)	
Yes	12 (21.82)	8 (14.52)	20 (18.18)	
Number of Recurrent Strokes				0.32
1	7 (12.73)	4 (7.27)	11 (10.00)	
2	3 (5.45)	4 (7.27)	7 (6.36)	
3	2 (3.64)	0 (0)	2 (1.88)	
Duration Since First Stroke (months), median (IQR)	2.00 (0.00, 21.50)	1.00 (0.00, 10.50)	1.50 (0.00, 15.75)	0.59
Duration Since Most Recent Stroke (months), median (IQR)	0.00 (0.00, 2.50)	0.00 (0.00, 3.00)	0.00 (0.00, 2.50)	0.65
mBI Score (0-100), median (IQR)	100.00 (67.00, 100.00)	100.00 (62.50, 100.00)	100.00 (65.25, 100.00)	0.62
Duration of HTN (months), median (IQR)	44.00 (9.50, 161.50)	58.00 (6.00, 127.50)	56.50 (9.00, 139.75)	0.84
HTN Medication, n (%)				1.00
Yes	38 (69.09)	38 (69.09)	76 (69.09)	
No	17 (30.91)	17 (30.91)	17 (30.91)	
MMAS-8 Score (0-8), median (IQR)	6.00 (3.38, 7.56)	6.00 (2.94, 7.00)	6.00 (3.12, 7.00)	0.83
Comorbidity, n (%)				0.34
CKD	2 (3.64)	3 (5.45)	5 (4.55)	
CVD	3 (5.45)	0 (0)	3 (2.73)	
DM	23 (41.82)	29 (52.73)	52 (47.27)	

Dyslipidaemia	25 (45.45)	22 (40.00)	47 (42.73)	
None	14 (25.45)	8 (14.55)	22 (20.00)	
Others	9 (16.36)	13 (23.64)	22 (20.00)	
Smoking Status, n (%)				0.65
Daily smoker	18 (32.73)	13 (23.64)	31 (28.18)	
Ex-smoker	6 (10.91)	9 (16.36)	15 (13.64)	
Never	29 (52.73)	30 (54.55)	59 (53.64)	
Occasionally	2 (3.64)	3 (5.45)	5 (4.55)	
Alcohol Consumption, n (%)				0.15
Daily drinker	6 (10.91)	1 (1.82)	7 (6.36)	
Never	32 (58.18)	39 (70.91)	71 (64.55)	
Occasionally	12 (21.82)	8 (14.55)	20 (18.18)	
Quit	5 (9.09)	7 (12.73)	12 (10.91)	
Regular Exercise, n (%)				0.85
No	25.00 (45.45)	23.00 (41.82)	48.00 (43.64)	
Yes	30.00 (54.55)	32.00 (58.18)	62.00 (56.36)	
Exercise Duration (hours/week), median (IQR)	4.55 (3.50, 7.00)	5.50 (3.50, 7.00)	4.80 (3.50, 7.00)	0.60
BMI (kg/m^2), mean (SD)	23.79 (2.39)	24.18 (3.33)	23.99 (2.90)	0.49
PHQ-4 Score (0-12), median (IQR)	1.00 (0.00, 4.00)	2.00 (0.00, 5.50)	2.00 (0.00, 4.75)	0.67
PHQ-2 (0-6), median (IQR)	0.00 (0.00, 2.00)	1.00 (0.00, 2.00)	0.00 (0.00, 2.00)	0.59
GAD-2 (0-6), median (IQR)	1.00 (0.00, 2.00)	1.00 (0.00, 2.50)	1.00 (0.00, 2.00)	0.83
Frequency of Home Breakfast (days/week), median (IQR)	7.00 (3.50, 7.00)	6.00 (4.00, 7.00)	7.00 (4.00, 7.00)	0.60
Frequency of Home Lunch (days/week), median (IQR)	7.00 (4.50, 7.00)	7.00 (6.00, 7.00)	7.00 (5.00, 7.00)	0.81
Frequency of Home Dinner (days/week), median (IQR)	7.00 (6.00, 7.00)	7.00 (6.00, 7.00)	7.00 (6.00, 7.00)	0.93
Use an SRS, n (%)				0.33
No	47 (85.45)	42 (76.36)	89 (80.91)	
Yes	8 (14.55)	13 (23.64)	21 (19.09)	
Add Less High-sodium Condiments, n (%)				0.18
No	32 (58.18)	24 (43.64)	56 (50.91)	
Yes	23 (41.82)	31 (56.36)	54 (49.09)	
Use Low-sodium Condiments, n (%)				0.63
No	46 (83.64)	43 (78.18)	89 (80.91)	
Yes	9 (16.36)	12 (21.82)	21 (19.09)	

Prioritise Natural Food and Less Processed Food, n (%)				1
No	11 (20.00)	11 (20.00)	22 (20.00)	
Yes	44 (80.00)	44 (80.00)	88 (80.00)	
Check Sodium Content in Nutrition Labels, n (%)				
No	51 (92.73)	50 (90.91)	101 (91.82)	1.00
Yes	4 (7.27)	5 (9.09)	9 (8.18)	
GCS Score (5-25), Mean (SD)	17.16 (4.50)	16.47 (3.24)	16.82 (3.92)	0.36
Perceived Social and Environmental Factor Score (8-40), median (IQR)	23.00 (19.00, 25.00)	22.00 (19.00, 25.50)	22.50 (19.00, 25.00)	0.67
KAP-K Score (0-15), median (IQR)	5.00 (0.00, 10.00)	5.00 (0.00, 10.00)	5.00 (0.00, 10.00)	0.55
KAP-A Score (0-15), median (IQR)	5.00 (2.50, 5.00)	5.00 (5.00, 5.00)	5.00 (5.00, 5.00)	0.99
KAP-P Score (0-30), median (IQR)	15.00 (11.50, 18.00)	16.00 (12.00, 19.00)	16.00 (12.00, 19.00)	0.62
KAP-Total Score (0-60), median (IQR)	23.00 (18.00, 32.00)	26.00 (17.00, 34.00)	24.00 (17.25, 33.00)	0.56
SBP, mean (SD)	136.27 (14.11)	136.22 (12.70)	136.24 (13.36)	0.98
DBP, mean (SD)	83.25 (10.55)	84.28 (10.92)	83.77 (10.70)	0.62
Self-efficacy Score (0-110), median (IQR)	81.00 (57.00, 98.50)	83.00 (60.00, 99.50)	82.00 (58.25, 99.00)	0.54
EQ-5D-3L Index, median (IQR)	0.78 (0.57, 0.88)	0.78 (0.51, 1.00)	0.78 (0.52, 1.00)	0.62
EQ-5D-3L VAS (0-100), median (IQR)	65.00 (50.00, 79.00)	60.00 (57.50, 73.50)	65.00 (51.25, 75.00)	0.88
DR Score (0-27), median (IQR)	10.00 (8.00, 13.00)	11.00 (9.50, 13.00)	11.00 (8.25, 13.00)	0.37

Note: BMI: Body Mass Index; CKD: Chronic Kidney Disease; CNY: Chinese Currency; CVD: Cardiovascular Disease; DBP: Diastolic Blood Pressure; DM: Diabetes Mellitus; DR: Dyadic Relationship; EQ-5D-3L: European Quality of Life 5-Dimension 3-Level; GAD-2: Generalised Anxiety Disorder-2; GCS: Goal Commitment Scale; HS: Haemorrhagic Stroke; HTN: Hypertension; IQR: Interquartile Range; IS: Ischaemic Stroke; KAP: Knowledge, Attitude, and Practice; KAP-A: Knowledge, Attitude, and Practice - Attitude; KAP-K: Knowledge, Attitude, and Practice - Knowledge; KAP-P: Knowledge, Attitude, and Practice - Practice; KAP-Total: Knowledge, Attitude, and Practice - Total Score; mBI: Modified Barthel Index; MMAS-8: Morisky Medication Adherence Scale - 8 Item; n: Number; PHQ-2: Patient Health Questionnaire – 2; PHQ-4: Patient Health Questionnaire - 4; SBP: Systolic Blood Pressure; SD: Standard Deviation; SRS: Salt Restriction Spoon; TIA: Transient Ischaemic Attack; VAS: Visual Analogue Scale.

Table 2. Baseline Characteristics of Family Caregivers (n=110)

Variables	Intervention group (n=55)	Control group (n=55)	All (n=110)	Between group p-value
Age (years), mean (SD)	49.66 (13.77)	53.08 (15.73)	51.37 (14.82)	0.23
Sex, n (%)				0.55
Female	33 (60.00)	37 (67.27)	70 (63.64)	
Male	22 (40.00)	18 (32.73)	40 (36.36)	
Education Level, n (%)				0.36
No formal education	0 (0)	1 (1.82)	1 (0.91)	
Primary school	4 (7.27)	2 (3.64)	6 (5.45)	
Junior high school	11 (20.00)	16 (29.09)	27 (24.55)	
Senior high school	17 (30.91)	20 (36.36)	37 (33.64)	
Undergraduate	21 (38.18)	16 (29.09)	37 (33.64)	
Master's degree or above	2 (3.64)	0 (0)	2 (1.82)	
Marital Status, n (%)				0.98
Divorced	3 (5.45)	2 (3.64)	5 (4.55)	
Married	44 (80.00)	45 (81.82)	89 (80.91)	
Single	7 (12.73)	7 (12.73)	14 (12.73)	
Widowed	1 (1.82)	1 (1.82)	2 (1.82)	
Employment Status, n (%)				0.06
Full-time	27 (49.09)	18 (32.73)	45 (40.91)	
Retired	18 (32.73)	22 (40.00)	40 (36.36)	
Self–employed	8 (14.55)	5 (9.09)	13 (11.82)	
Unemployed	2 (3.64)	6 (10.91)	8 (7.27)	
Part-time	0 (0)	4 (7.27)	4 (3.64)	
Relationship to stroke survivors				0.35
Spouse/partner	21 (38.18)	30 (54.55)	51 (46.36)	
Children	24 (43.64)	19 (34.55)	43 (39.09)	
Parents	5 (9.09)	2 (3.64)	7 (6.36)	
Siblings	4 (7.27)	2 (3.64)	6 (5.45)	
Other relatives	1 (1.82)	2 (3.64)	3 (2.73)	
Co-reside with the stroke survivor, n (%)				0.67
No	17 (30.91)	14 (25.45)	31 (28.18)	
Yes	38 (69.09)	41 (74.55)	79 (71.82)	
Perceived Dyadic Typology, n (%)				0.40
Collaborative	15 (27.27)	16 (29.09)	31 (28.18)	
Complementary	13 (23.64)	8 (14.55)	21 (19.09)	
Family-oriented	12 (21.82)	9 (16.36)	21 (19.09)	

Patient-oriented	15 (27.27)	22 (40.00)	37 (33.64)	
Proficient in WeChat Use (1-5), median (IQR)	4 (4.00, 5.00)	4.00 (4.00, 5.00)	4.00 (4.00, 5.00)	0.22
PHQ-4 Score (0-12), median (IQR)	1.00 (0.00 to 4.00)	0.00 (0.00 to 4.00)	1.00 (0.00 to 4.00)	0.29
PHQ-2 (0-6), median (IQR)	1.00 (0.00 to 2.00)	0.00 (0.00 to 2.00)	0.00 (0.00 to 2.00)	0.26
GAD-2 (0-6), median (IQR)	1.00 (0.00 to 2.00)	0.00 (0.00 to 2.00)	0.00 (0.00 to 2.00)	0.51
Disease, n (%)				0.53
CVD	3 (5.45)	2 (3.64)	5 (4.55)	
Chronic Respiratory Disease	0 (0)	1 (1.81)	1 (0.91)	
DM	5 (9.09)	11 (20.00)	16 (14.55)	
Dyslipidaemia	7 (12.72)	5 (9.09)	12 (10.91)	
HTN	15 (27.27)	15 (27.27)	30 (27.27)	
Stroke	2 (3.64)	2 (3.64)	4 (3.36)	
Others	7 (12.72)	3 (5.45)	10 (9.10)	
None	32 (58.15)	30 (54.55)	62 (56.36)	
Frequency of Home Breakfast (days/week), median (IQR)	6.00 (3.00, 7.00)	6.00 (5.00, 7.00)	6.00 (3.25, 7.00)	0.44
Frequency of Home Lunch (days/week), median (IQR)	5.00 (2.50, 7.00)	7.00 (5.00, 7.00)	6.00 (4.00, 7.00)	0.02
Frequency of Home Dinner (days/week), median (IQR)	6.00 (5.00, 7.00)	6.00 (5.00, 7.00)	6.00 (5.00, 7.00)	0.33
Use an SRS, n (%)				0.11
No	39 (70.91)	30 (54.55)	69 (62.73)	
Yes	16 (29.09)	25 (45.45)	41 (37.27)	
Add Less High-sodium Condiments, n (%)				0.32
No	22 (40.00)	16 (29.09)	38 (34.55)	
Yes	33 (60.00)	39 (70.91)	72 (65.45)	
Use Low-sodium Condiments, n (%)				0.33
No	36 (65.45)	30 (54.55)	66 (60.00)	
Yes	19 (34.55)	25 (45.45)	44 (40.00)	
Prioritise Natural Food and Less Processed Food, n (%)	36 (65.45)	30 (54.55)	66 (60.00)	1.00
No	5 (9.09)	6 (10.91)	11 (10.00)	
Yes	50 (90.91)	49 (89.09)	99 (90.00)	
Check Sodium Content in Nutrition Labels, n (%)				0.07
No	47 (85.45)	38 (69.09)	85 (77.27)	
Yes	8 (14.55)	17 (30.91)	25 (22.73)	

GCS Score (5-25), median (IQR)	18.00 (15.00, 20.00)	17.00 (15.00, 20.00)	17.00 (15.00, 20.00)	0.48
Perceived Social and Environmental Factor Score (8-40), mean (SD)	24.95 (4.43)	24.98 (5.75)	24.96 (5.11)	0.97
KAP-K Score (0-15), median (IQR)	10.00 (5.00, 15.00)	10.00 (2.50-10.00)	10.00 (5.00, 15.00)	0.13
KAP-A Score (0-15), median (IQR)	10.00 (10.00, 15.00)	10.0 (10.00, 12.50)	10.00 (10.00, 15.00)	0.28
KAP-P Score (0-30), mean (SD)	16.73 (5.29)	17.98 (5.72)	17.35 (5.52)	0.24
KAP-Total Score (0-60), mean (SD)	36.73 (10.13)	35.80 (12.18)	36.26 (11.16)	0.67
Self-efficacy Score (0-40), median (IQR)	25.00 (21.50, 30.00)	26.00 (20.00, 32.00)	26.00 (20.00, 30.75)	0.93
DR Score (0-30), mean (SD)	10.76 (4.78)	10.91 (4.02)	10.84 (4.39)	0.86
Caregiving Burden (0-16), median (IQR)	4.00 (2.00, 6.00)	4.00 (0.00, 5.50)	4.00 (1.00, 6.00)	0.24

Note: CVD: Cardiovascular Disease; DM: Diabetes Mellitus; DR: Dyadic Relationship; GAD-2: Generalised Anxiety Disorder-2; GCS: Goal Commitment Scale; HTN: Hypertension; IQR: Interquartile Range; KAP: Knowledge, Attitude, and Practice; KAP-A: Knowledge, Attitude, and Practice–Attitude; KAP-K: Knowledge, Attitude, and Practice–Knowledge; KAP-P: Knowledge, Attitude, and Practice–Practice; PHQ-2: Patient Health Questionnaire-2; PHQ-4: Patient Health Questionnaire-4; SD: Standard Deviation; SRS: Salt Restriction Spoon.

Table 3. Intervention Effects in Stroke Survivors (n=110)

	Intervention group (n=55)			Control group (n=55)			Between-group difference		adjusted GEE [#]		Cohen's d
	Estimated mean (95%CI)	Within-group change from baseline (95%CI)	P value	Estimated mean (95%CI)	Within-group change from baseline (95%CI)	P value	Estimated mean (95%CI)	P value	Group * Time Interaction Coefficient [β] (95%CI)	P value for Group * Time Interaction	
KAP-K											
T0	4.55 (3.18, 5.91)	NA	NA	5.00 (3.69, 6.31)	NA	NA	-0.45 (-2.34, 1.44)	0.64	NA	NA	NA
T1	12.27 (11.02, 13.53)	7.73 (6.06, 9.40)	< 0.001	8.45 (6.75, 10.16)	3.45 (1.80, 5.10)	< 0.001	3.82 (1.70, 5.94)	< 0.001	4.27 (1.93, 6.62)	< 0.001	0.67
T2	13.00 (11.73, 14.28)	8.46 (6.65, 10.27)	< 0.001	10.10 (8.55, 11.65)	5.10 (3.35, 6.85)	< 0.001	2.90 (0.92, 4.89)	< 0.001	3.36 (0.86, 5.85)	0.01	0.55
KAP-A											
T0	4.82 (3.91, 5.73)	NA	NA	4.82 (4.02, 5.61)	NA	NA	0.00 (-1.21, 1.21)	1.00	NA	NA	NA
T1	12.27 (11.04, 13.50)	7.45 (5.84, 9.07)	< 0.001	9.18 (7.76, 10.60)	4.36 (2.77, 5.96)	< 0.001	3.09 (1.21, 4.97)	< 0.001	3.09 (0.82, 5.36)	0.01	0.51
T2	12.92 (11.81, 14.03)	8.10 (6.64, 9.56)	< 0.001	10.52 (9.26, 11.79)	5.71 (4.28, 7.13)	< 0.001	2.40 (0.73, 4.07)	0.01	2.40 (0.38, 4.42)	0.02	0.50
KAP-P											
T0	15.16 (13.65, 16.67)	NA	NA	15.55 (14.17, 16.92)	NA	NA	-0.38 (-2.43, 1.66)	0.71	NA	NA	NA
T1	21.96 (20.58, 23.35)	6.80 (5.08, 8.51)	< 0.001	19.27 (17.65, 20.89)	3.73 (1.93, 5.53)	< 0.001	2.69 (0.54, 4.85)	0.01	3.07 (0.57, 5.58)	0.02	0.48
T2	22.22 (20.58, 23.86)	7.06 (5.05, 9.06)	< 0.001	19.15 (17.40, 20.90)	3.61 (1.61, 5.60)	< 0.001	3.07 (0.66, 5.48)	0.01	3.45 (0.62, 6.28)	0.02	0.51
KAP-Total											

T0	24.53 (21.81, 27.24)	NA	NA	25.36 (22.70, 28.03)	NA	NA	-0.84 (-4.64, 2.97)	0.67	NA	NA	NA
T1	46.51 (43.54, 49.48)	21.98 (18.40, 25.56)	< 0.001	36.91 (33.06, 40.75)	11.54 (7.75, 15.33)	< 0.001	9.60 (4.74, 14.47)	< 0.001	10.44 (5.22, 15.66)	< 0.001	0.75
T2	48.14 (45.01, 51.28)	23.62 (19.57, 27.66)	< 0.001	39.78 (36.29, 43.27)	14.41 (10.71, 18.12)	< 0.001	8.37 (3.63, 13.10)	< 0.001	9.20 (3.70, 14.70)	< 0.001	0.71
SBP											
T0	136.27 (132.57, 139.96)	NA	NA	136.22 (132.89, 139.54)	NA	NA	0.05 (-4.92, 5.02)	0.98	NA	NA	NA
T1	127.50 (124.17, 130.83)	-8.77 (-11.13, -6.41)	< 0.001	133.64 (130.23, 137.04)	-2.58 (-5.57, 0.42)	0.09	-6.14 (-10.84, -1.44)	0.01	-6.19 (-9.92, -2.47)	< 0.001	-0.64
T2	127.20 (123.66, 130.73)	-9.07 (-12.00, -6.14)	< 0.001	131.30 (127.90, 134.70)	-4.92 (-7.99, -1.84)	< 0.001	-4.10 (-8.78, 0.58)	0.09	-4.15 (-8.13, -0.18)	0.04	-0.42
DBP											
T0	83.25 (80.49, 86.02)	NA	NA	84.28 (81.42, 87.14)	NA	NA	-1.02 (-5.00, 2.95)	0.61	NA	NA	NA
T1	77.85 (75.26, 80.45)	-5.40 (-7.23, -3.58)	< 0.001	82.53 (79.70, 85.35)	-1.75 (-4.14, 0.64)	0.15	-4.67 (-8.50, -0.85)	0.02	-3.65 (-6.64, -0.66)	0.02	-0.49
T2	78.95 (76.52, 81.37)	-4.31 (-6.27, -2.34)	< 0.001	81.55 (79.06, 84.04)	-2.73 (-5.31, -0.15)	0.04	-2.60 (-6.03, 0.82)	0.14	-1.58 (-4.76, 1.60)	0.33	-0.20
Self-efficacy											
T0	74.02 (66.49, 81.55)	NA	NA	76.69 (69.01, 84.37)	NA	NA	-2.67 (-13.43, 8.08)	0.63	NA	NA	NA
T1	90.48 (84.69, 96.26)	16.46 (10.67, 22.24)	< 0.001	84.00 (77.00, 91.00)	7.31 (0.37, 14.25)	0.04	6.47 (-2.47, 15.41)	0.16	9.15 (0.26, 18.03)	0.04	0.39

T2	92.98 (86.51, 99.45)	18.96 (13.08, 24.84)	< 0.001	88.98 (83.01, 94.95)	12.29 (5.37, 19.20)	< 0.001	4.00 (-4.87, 12.87)	0.38	6.67 (-2.45, 15.80)	0.15	0.29
QoL (EQ-5D-3L_index)											
T0	0.71 (0.64, 0.78)	NA	NA	0.72 (0.65, 0.80)	NA	NA	-0.01 (-0.11, 0.09)	0.84	NA	NA	NA
T1	0.88 (0.83, 0.93)	0.17 (0.11, 0.23)	< 0.001	0.84 (0.78, 0.90)	0.11 (0.05, 0.18)	< 0.001	0.04 (-0.03, 0.12)	0.26	0.05 (-0.03, 0.14)	0.22	0.24
T2	0.90 (0.84, 0.95)	0.18 (0.12, 0.25)	< 0.001	0.86 (0.80, 0.91)	0.13 (0.06, 0.20)	< 0.001	0.04 (-0.04, 0.11)	0.31	0.05 (-0.05, 0.15)	0.31	0.20
QoL (EQ-5D-3L_VAS)											
T0	64.07 (59.48, 68.67)	NA	NA	64.82 (61.14, 68.50)	NA	NA	-0.75 (-6.63, 5.14)	0.80	NA	NA	NA
T1	75.80 (71.95, 79.65)	11.73 (8.10, 15.36)	< 0.001	74.48 (70.82, 78.14)	9.66 (6.02, 13.31)	< 0.001	1.32 (-3.93, 6.58)	0.62	2.07 (-3.01, 7.15)	0.43	0.16
T2	78.12 (74.41, 81.83)	14.05 (10.81, 17.28)	< 0.001	76.97 (73.63, 80.32)	12.16 (8.45, 15.86)	< 0.001	1.14 (-3.91, 6.20)	0.66	1.89 (-3.08, 6.86)	0.46	0.15
DR											
T0	10.13 (9.11, 11.14)	NA	NA	10.76 (9.94, 11.59)	NA	NA	-0.64 (-1.94, 0.67)	0.34	NA	NA	NA
T1	7.69 (6.67, 8.71)	-2.44 (-3.33, -1.54)	< 0.001	9.74 (8.57, 10.90)	-1.02 (-2.25, 0.21)	0.10	-2.05 (-3.55, -0.54)	0.01	-1.41 (-2.89, 0.06)	0.06	-0.37
T2	7.31 (6.23, 8.39)	-2.82 (-4.10, -1.53)	< 0.001	9.61 (8.58, 10.64)	-1.15 (-2.20, -0.11)	0.03	-2.30 (-3.77, -0.82)	< 0.001	-1.66 (-3.30, -0.03)	0.047	-0.41

Note: #: adjusted covariates in the GEE model included baseline values, age, sex, education level, marital status, employment, and perceived dyadic typology; antihypertensive medication use was additionally adjusted for SBP and DBP outcomes only.

Abbreviation: CI: Confidence Interval; DBP: Diastolic Blood Pressure; DR: Dyadic Relationship; EQ-5D-3L: European Quality of Life 5-

Dimension 3-Level; GEE: Generalised Estimating Equation; KAP: Knowledge, Attitude, and Practice; KAP-A: Knowledge, Attitude, and Practice - Attitude; KAP-K: Knowledge, Attitude, and Practice - Knowledge; KAP-P: Knowledge, Attitude, and Practice - Practice; KAP-Total: Knowledge, Attitude, and Practice - Total Score; NA: Not Available; QoL: Quality of Life; SBP: Systolic Blood Pressure; VAS: Visual Analogue Scale.

Table 4. Intervention Effects in Family Caregivers (n=110)

	Intervention group (n=55)			Control group (n=55)			Between-group difference		adjusted GEE #		Cohen's d
	Estimated mean (95%CI)	Within-group change from baseline (95%CI)	P value	Group * Time Interaction Coefficient	Group * Time Interaction Coefficient	P value	Estimated mean (95%CI)	P value	Group * Time Interaction Coefficient [β] (95%CI)	P value for Group * Time Interaction	
KAP-K											
T0	9.09 (7.73, 10.45)	NA	NA	7.45 (5.99, 8.92)	NA	NA	1.64 (-0.36, 3.64)	0.11	NA	NA	NA
T1	13.95 (13.15, 14.75)	4.86 (3.33, 6.39)	< 0.001	10.55 (9.02, 12.08)	3.10 (1.51, 4.69)	< 0.001	3.40 (1.66, 5.14)	< 0.001	1.76 (-0.45, 3.97)	0.12	0.31
T2	13.31 (12.25, 14.36)	4.22 (2.60, 5.83)	< 0.001	9.84 (8.39, 11.29)	2.39 (0.79, 3.99)	< 0.001	3.47 (1.70, 5.23)	< 0.001	1.83 (-0.41, 4.07)	0.11	0.33
KAP-A											
T0	10.91 (9.81, 12.01)	NA	NA	10.36 (9.43, 11.30)	NA	NA	0.55 (-0.90, 1.99)	0.46	NA	NA	NA
T1	13.67 (12.86, 14.49)	2.76 (1.56, 3.97)	< 0.001	11.78 (10.73, 12.83)	1.42 (0.24, 2.59)	0.02	1.89 (0.56, 3.22)	0.01	1.35 (-0.33, 3.03)	0.12	0.32
T2	13.24 (12.43, 14.05)	2.33 (1.14, 3.51)	< 0.001	11.53 (10.57, 12.49)	1.16 (0.03, 2.30)	0.04	1.71 (0.43, 2.99)	0.01	1.16 (-0.49, 2.81)	0.17	0.28
KAP-P											
T0	16.73 (15.34, 18.11)	NA	NA	17.98 (16.48, 19.48)	NA	NA	-1.25 (-3.29, 0.79)	0.23	NA	NA	NA
T1	21.75 (20.45, 23.04)	5.02 (3.48, 6.56)	< 0.001	18.38 (16.57, 20.19)	0.40 (-1.34, 2.15)	0.65	3.37 (1.11, 5.62)	< 0.001	4.62 (2.27, 6.97)	< 0.001	0.80
T2	20.76 (19.31, 22.20)	4.03 (2.20, 5.86)	< 0.001	18.65 (16.97, 20.33)	0.67 (-0.96, 2.30)	0.42	2.10 (-0.10, 4.30)	0.06	3.36 (0.93, 5.78)	0.01	0.57

KAP-Total											
T0	36.73 (34.07, 39.38)	NA	NA	35.80 (32.61, 38.99)	NA	NA	0.93 (-3.22, 5.08)	0.66	NA	NA	NA
T1	49.40 (47.35, 51.44)	12.67 (9.91, 15.43)	< 0.001	40.71 (37.12, 44.30)	4.91 (1.39, 8.44)	0.01	8.68 (4.56, 12.81)	< 0.001	7.75 (3.29, 12.22)	< 0.001	0.68
T2	47.30 (45.13, 49.48)	10.57 (7.65, 13.50)	< 0.001	40.02 (36.96, 43.09)	4.22 (1.17, 7.27)	0.01	7.28 (3.55, 11.01)	< 0.001	6.35 (2.16, 10.55)	< 0.001	0.60
Self-efficacy											
T0	26.20 (24.58, 27.82)	NA	NA	25.71 (23.81, 27.61)	NA	NA	0.49 (-2.00, 2.98)	0.70	NA	NA	NA
T1	29.39 (27.94, 30.85)	3.19 (2.10, 4.29)	< 0.001	26.58 (24.87, 28.30)	0.87 (-1.08, 2.83)	0.38	2.81 (0.54, 5.08)	0.02	2.32 (0.06, 4.58)	0.04	0.40
T2	28.55 (27.02, 30.07)	2.35 (0.70, 3.99)	0.01	27.17 (25.41, 28.93)	1.46 (-0.21, 3.13)	0.09	1.38 (-0.94, 3.70)	0.24	0.89 (-1.44, 3.21)	0.46	0.15
DR											
T0	10.76 (9.51, 12.01)	NA	NA	10.91 (9.86, 11.96)	NA	NA	-0.15 (-1.78, 1.49)	0.86	NA	NA	NA
T1	9.45 (8.10, 10.81)	-1.31 (-2.37, -0.26)	0.02	10.85 (9.63, 12.08)	-0.06 (-1.18, 1.06)	0.92	-1.40 (-3.23, 0.42)	0.13	-1.26 (-2.79, 0.28)	0.11	-0.32
T2	9.45 (8.31, 10.58)	-1.32 (-2.52, -0.11)	0.03	10.48 (9.19, 11.78)	-0.42 (-1.64, 0.79)	0.49	-1.04 (-2.74, 0.66)	0.23	-0.89 (-2.57, 0.79)	0.30	-0.22
Caregiver burden											
T0	4.53 (3.63, 5.42)	NA	NA	4.00 (3.00, 5.00)	NA	NA	0.53 (-0.81, 1.87)	0.44	NA	NA	NA

T1	3.17 (2.30, 4.04)	-1.36 (-2.10, -0.62)	< 0.001	3.57 (2.57, 4.58)	-0.43 (-1.39, 0.54)	0.39	-0.40 (-1.74, 0.94)	0.56	-0.93 (-2.16, 0.30)	0.14	-0.29
T2	2.69 (2.03, 3.34)	-1.84 (-2.68, -1.00)	< 0.001	2.54 (1.79, 3.30)	-1.46 (-2.27, -0.64)	< 0.001	0.15 (-0.87, 1.16)	0.78	-0.38 (-1.57, 0.80)	0.53	-0.13

Note: #: adjusted covariates in the GEE model included baseline values, age, sex, education level, marital status, and employment, and perceived dyadic typology.

Abbreviation: CI: Confidence Interval; DR: Dyadic Relationship; GEE: Generalised Estimating Equation; KAP: Knowledge, Attitude, and Practice; KAP-A: Knowledge, Attitude, and Practice–Attitude; KAP-K: Knowledge, Attitude, and Practice–Knowledge; KAP-P: Knowledge, Attitude, and Practice–Practice; NA: Not Available.

Table 5. Regular Message Structure Integrating SCT and BCTs

Module	Contents	SCT	BCTs
Module 1: Introduction	• Programme background, medical emergency protocol, duration, and contents	• Knowledge	• 5.1 information about health consequences
Module 2: Sodium and Health	• Education on stroke, HTN, and high sodium intake (health impacts and misconceptions), sodium intake sources and recommended levels • Home blood pressure measurement skills • Goal setting for blood pressure control and sodium intake reduction	• Knowledge • Outcome expectancies • Self-efficacy • Goals	• 5.1 information about health consequences • 5.3 information about social and environmental consequences • 4.1 instruction on how to perform the behaviour • 6.1. demonstration of the behaviour • 1.3 goal setting (outcome)
Module 3: Home Cooking Master **Module 4: Food Shopping Expert** **Module 5: Food Ordering Specialist**	• Sodium intake reduction skill introduction and demonstration: 4, 2, and 2 skills for home cooking, grocery shopping, and dining out, respectively • Goal setting examples on each skill, and share thoughts and barriers faced on each skill	• Knowledge • Outcome expectancies • Self-efficacy • Socio-structural facilitators/barriers • Goals	• 5.1 information about health consequences • 5.3 information about social and environmental consequences • 4.1 instruction on how to perform the behaviour, • 8.1 behavioural practice/rehearsal • 6.1. demonstration of the behaviour • 15.1 verbal persuasion about capability • 3.2 social support (practical) • 3.3 social support (emotional) • 1.1 goal setting (behaviour)
Module 6: Summary	Knowledge and skills summary	• Knowledge • Self-efficacy	• 5.1 information about health consequences • 5.3 information about social and environmental consequences • 4.1 instruction on how to perform the behaviour

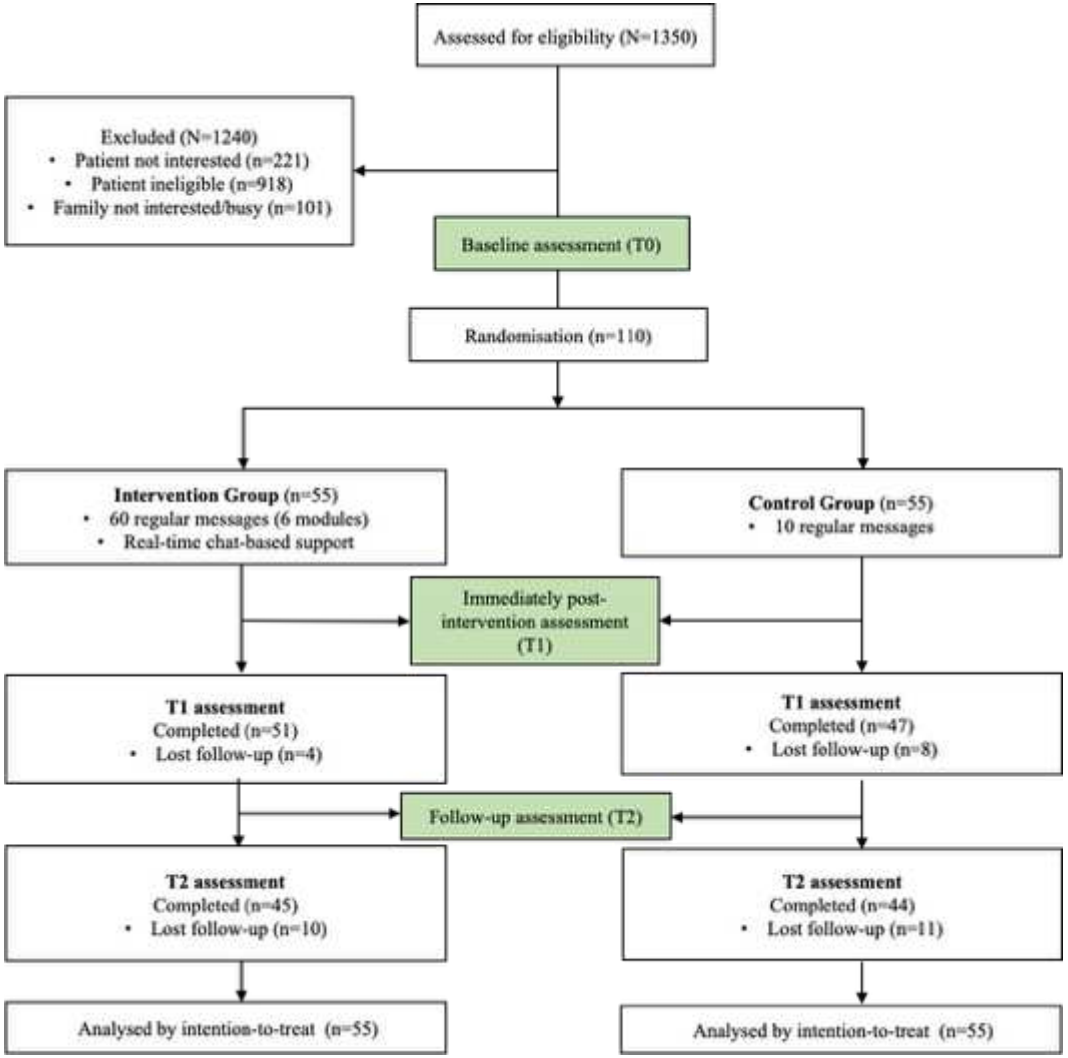
Note: BCTs: Behaviour Change Techniques; SCT: Social Cognitive Theory.

Table 6: Data Collection Procedure

	Baseline (T0)		**Immediately post-intervention assessment (T1)**		**Follow-up assessment (T2)**	
	Stroke survivor	**Family caregiver**	**Stroke survivor**	**Family caregiver**	**Stroke survivor**	**Family caregiver**
Demographic Data	+	+				
Health Data	+	+	+		+	
Dietary Data	+	+	+	+	+	+
Message Receiving Preference	+	+				
KAP regarding Sodium Intake Reduction	+	+	+	+	+	+
SBP and DBP	+		+		+	
Self-efficacy	+	+	+	+	+	+
QoL	+		+		+	
DR	+	+	+	+	+	+
Caregiving Burden		+		+		+
Intervention Satisfaction and Usefulness			+	+	+	+

Note: "+" indicated data collection at the specified time point; DBP: Diastolic Blood Pressure; DR: Dyadic Relationship; KAP: Knowledge, Attitude, Practice; QoL: Quality of Life; SBP: Systolic Blood Pressure. "+" indicates data collection at the specified time point.

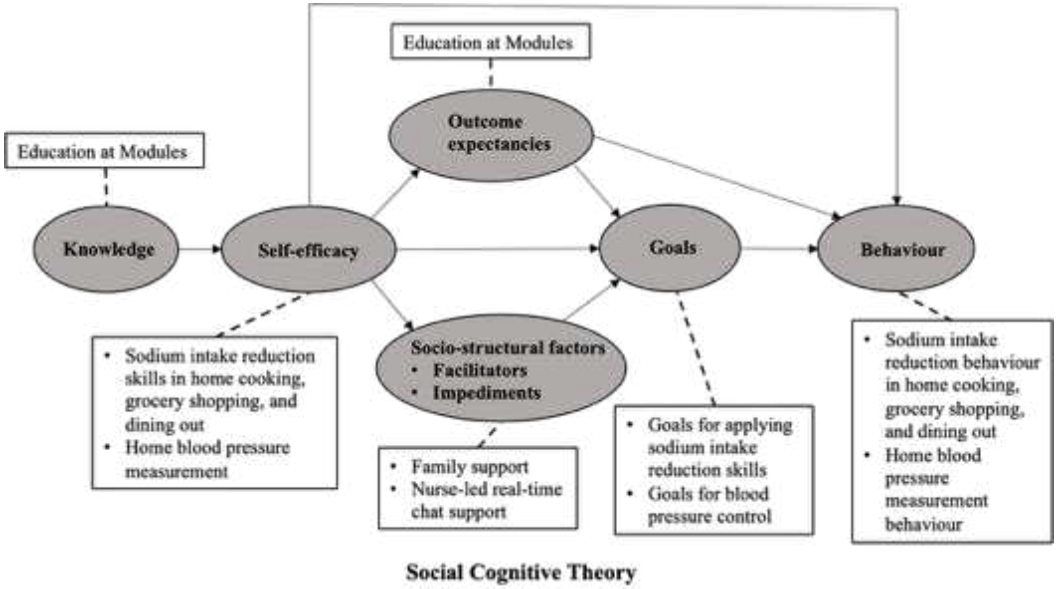
Figure 1. CONSORT Flow Chart



This CONSORT flow chart outlines the screening, recruitment, randomisation, intervention, and follow-up process. Of 1,350 patients screened, 918 did not meet inclusion criteria, 221 declined participation, and 101 caregivers were not interested or unavailable. A total of 110 dyads were

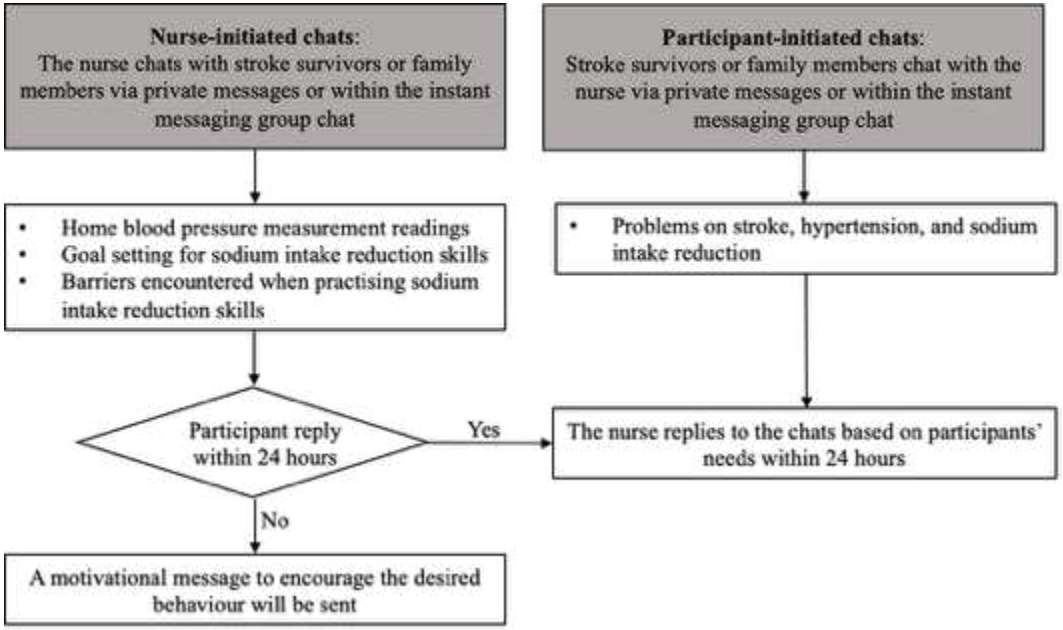
enrolled and randomised. At T1 (post-intervention), 51 and 47 dyads completed assessments in the intervention and control groups, with 4 and 8 lost to follow-up, respectively. At T2 (2 months post-intervention), 45 and 44 dyads completed assessments, with 10 and 11 lost to follow-up, respectively. Loss to follow-up was due to withdrawal of consent, removal of the interventionist's WeChat, or death (intervention group only).

Figure 2. Conceptual Model of the Intervention



Note: Incorporation of SCT structural paths of influence (shaded oval boxes) and a nurse-led, instant message-delivered dyadic intervention to reduce sodium intake in stroke survivors with hypertension (rectangular boxes). SCT, Social Cognitive Theory.

Figure 3. The Nurse-led Real-time Chat Support Protocol



Note: Nurse-led real-time chat support comprised two scenarios: participant-initiated chats and nurse-initiated chats. In both scenarios, the nurse provided personalised messages addressing participants' specific needs during the intervention, such as goal setting, behaviour change monitoring, and home blood pressure monitoring.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- SupplementaryTable.docx
- SupplementaryFigure.docx
- SupplementaryCheclikst1CONSORT2025.docx
- SupplementaryCheclikst2TIDieRtelehealth.docx