INVITED: STROKE/2023/045888

Title: The interventions that support lifestyle behavior change for secondary prevention of stroke: a scoping review

Short title: Lifestyle behavior change interventions for stroke

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Total number of Tables and Figures: Tables = 2, Figures = 2.
Word count: 10922

Keywords: Stroke, Secondary Prevention, Lifestyle, Behavior Change

Non-standard Abbreviations and Acronyms:

BCTs: behavior change techniques

BMI: body mass index

BP: blood pressure

CCM: chronic care model

CT: control theory

HBM: health belief model

HDL: high-density lipoprotein

HET: health empowerment theory

LDL: low-density lipoprotein

QED: quasi-experimental research design

SCT: social cognitive theory

SDT: self-determination theory

SET: self-efficacy theory

SM: self-care model

TF: theoretical framework

TIA: transient ischemic attack

TTM: transtheoretical model

Abstract (243/250 Words)

Lifestyle behavioral change is a critical component for secondary prevention of stroke. Although evidence for the effectiveness of lifestyle behavior change is growing, methods to promote and maintain behavior change remain unclear. In this review, we aimed to synthesize the evidence for lifestyle behavior change interventions among patients living with stroke or transient ischemic attack (TIA). We searched seven databases to identify studies, including randomized controlled trials, quasi-experimental, and longitudinal studies examining changes in cardiovascular risk factors. Data were extracted regarding participant characteristics, intervention attributes (e.g., provider, behavior change techniques, modality), and effectiveness for control of risk factors. From 4620 records identified, 73 studies were included. Information regarding the type of behavior change theory applied were reported in 36% of studies. The social cognitive theory and transtheoretical models were the most commonly cited frameworks. Changes in physical activity (63%) and blood pressure (63%) were the most frequently assessed outcomes. Fewer than half of the studies assessed changes in weight (40%), blood cholesterol (40%), diet (34%), smoking cessation (33%), alcohol consumption (19%), and blood glucose (19%). No studies assessed sleep as a risk factor. Most studies had mixed effects or no change for the risk factor measured. No studies reported negative effects. Interventions associated with improvements were more commonly delivered by a multidisciplinary team and informed by behavior change techniques. Further research is

required to identify the most effective methods to promote and sustain lifestyle behavior change among people living with stroke or TIA.

Introduction

Globally, there are over 101 million survivors of stroke, and 12.2 million new strokes occur each year.[1] Advances in the clinical management of acute stroke in the past decade have increased the number of people living with stroke in the community.[2] However, survivors of stroke have a 6 to 15-fold increased risk of recurrent stroke, and those with multiple risk factors (i.e., > 1 risk factor) are at greater risk.[3,4] Recurrent stroke is associated with increased risk of death (25% within 28 days) and contributes to greater disability, dependency, or institutionalisation.[5]

As identified in the INTERSTROKE study, 10 modifiable risk factors account for approximately 90% of the attributable risk of stroke.[6] These risk factors (e.g., high blood pressure or smoking) can be treated or modified through healthy lifestyle changes.[7] However, unhealthy lifestyles are still common among people living with stroke.[2,8] As a rapid way to measure cardiovascular health, the American Heart Association developed the Life's Simple 7,[9] recently updated to the Life's Essential 8 to include sleep as an emerging risk factor.[10] These measures can be categorized into health behaviors (i.e., physical activity, smoking cessation, diet, and sleep) and health factors (i.e., blood cholesterol, blood sugar, blood pressure, and weight).[10] In addition to the above risk factors, alcohol consumption has been associated with an increased risk of stroke,[11] and is also an important lifestyle risk factor to be

targeted. The greater the number of risk factors per individual, the greater the risk of stroke.[6] Therefore, targeting multiple risk factors using different approaches may be beneficial for behavioral change interventions.

Multi-component programs using risk communication strategies (e.g., education, use of technology) and behavior change techniques (e.g., goal setting, feedback), based on theoretical frameworks, may effectively influence behavioral change and long-term risk modification.

While interventions promoting lifestyle behavior change have demonstrated benefit among people living with stroke,[12] evidence for the most effective features/characteristics of interventions (e.g. mode of delivery and behavior change techniques used) remains unclear.[13] Therefore, the overall aim of this scoping review was to synthesize the available evidence on the characteristics and effectiveness on cardiovascular risk factor management of interventions that support lifestyle behavioral change in people living with stroke or transient ischemic attack (TIA). We also aimed to assess whether these interventions have sustained effects on lifestyle change following stroke.

Methods

The scoping review was guided by Arksey and O'Malley's methodological framework.[14] The protocol of this scoping review was registered in advance in Open Science Framework,[15] with

reporting adhering to the Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist (Supplemental File S1).[16] The search was conducted in CINAHL, Cochrane, Embase, Ovid Medline, PsycINFO, Scopus, and Web of Science. The elements in the search queries followed the adapted version of Population, Intervention, Comparison, Outcome (PICO) structure, with the search strategy provided in the published protocol.[15]

Studies were included if the authors reported on interventions targeting people living with stroke or TIA aged ≥18 years, with the assessment of at least one of the Life's Essential 8 cardiovascular risk factors (physical activity, smoking, diet, sleep, body weight, blood lipids, blood glucose, blood pressure (BP)) with the addition of alcohol consumption. Randomized controlled trials (RCTs), quasi-experimental, mixed methods, and longitudinal studies exploring were included. Qualitative studies, cross-sectional studies, protocols, conference abstracts, case reports, expert opinions, editorials, and letters to the editor were excluded. Potentially eligible studies were independently assessed for inclusion. Following the removal of duplicates, three authors (LB, LPA, TT) screened the titles and abstracts for eligibility using the above criteria. Disagreements were resolved through discussion with another author (MB). Full texts of eligible abstracts were retrieved and assessed for inclusion by one author (LB), with a subset of full texts assessed by two authors (TT & LPA). Inconsistencies were discussed among the four authors (LB, TT, MB & LPA).

Using a pre-determined data extraction sheet, information on study characteristics (e.g., year, study design), and intervention features and effects (e.g., frequency, modality, theoretical framework, study outcomes) were extracted and summarized by one author (LB). Extracted data were checked for accuracy by two authors (TT & LPA). A narrative account was organized by the study characteristics, interventions, and outcomes, including information on sustained effects. Outcomes were reported as positive change where risk factors were improved (e.g., reduced body weight, or increase in physical activity measures), neutral if unchanged, and negative if worsened. Due to multiple measures used for each risk factor, mixed effects were also possible.

Results

The search yielded 4620 records, with 73 studies retained (Figure 1; Table 1). The majority of studies were RCTs (81%) and from high-income countries (85%), published between the years of 2000 and 2023. The study cohort size ranged from 24 to 3,678 participants (total of 16,520), with ages ranging from 41 to 73 years, and the proportion of women from 2% to 74%. Three studies did not report participant sex. The majority of studies included both ischemic and hemorrhagic stroke diagnoses (81%), with only ischemic stroke and TIA included in 14 studies (19%), and people with TIA only in 29 studies (40%). Time from stroke symptom onset of the included participants ranged from 2 days to 10 years. Fourteen studies (19%) were conducted in the community, home or primary care settings, and one was

in an exercise physiology laboratory. Nine studies (12%) had information about the living distance to the closest intervention sites, with nearly all sites being within 20 to 50 miles. Two studies did not have information on specific distance requirements, but did mention commute times or the requirement to live in close proximity.[17,18]

Intervention Attributes

One-third of studies were based on using a theoretical framework of behavior change to develop and deliver the intervention. Amongst these studies, 14 different types of theoretical frameworks were described (Table 1). The frameworks used included the Social Cognitive Theory (SCT),[19] Transtheoretical Model (TTM),[20] and Behavior Change Theory.[21] The SCT and TTM were the most commonly used frameworks (i.e., 9 studies).

Using the behavior change taxonomy, [22] 59 of the 73 studies (81%) studies described the behavior change techniques adopted in the intervention.[22] Goal setting (45%) was the most commonly used, followed by feedback (36%) and motivational interviewing (27%). Twenty-one (29%) studies mentioned inclusion of other participants (e.g., family caregiver) to support and promote behavior change.

Interventions were most commonly delivered using technology combined with face-to-face methods (e.g., in-person counselling with telephone calls) (68%), followed by studies using solely face-to-face methods (e.g., in-person individualized counselling, group activities) (34%) and technology-based interventions (e.g., telephone call, smartphone application)

(32%). Regardless of the mode of delivery, the changes in risk factors were mixed, showing either positive or neutral effects (Table 1).

Most interventions were delivered by multidisciplinary teams (45%), that included a neurologist, physiotherapist, and a nurse. Interventions conducted solely by nurses accounted for 15% of studies, by a researcher or health professional in 14%, by trained students in 4%, and by others (dietician, physician, neurologist, lifestyle coach, occupational therapist or physical therapist) in 19%. The person responsible for delivering the intervention was unclear in 3% of the studies.[23,24] Regardless of who was responsible for delivering the intervention (i.e., nurses compared to a multidisciplinary approach), the intervention effects on the various risk factors were mixed (Table 1).

Study duration ranged from 3 weeks to 36 months. Nearly 23% of the studies reported delivery of an intervention for less than three months, 37% for 3 - 6 months, 19% for 6 - 12 months, and nearly 21% extended to a year or more. Regardless of intervention duration, the effects on cardiovascular risk factors were mixed (Table 1).

Effectiveness of interventions on cardiovascular lifestyle risk factors

A total of 47 (64%) studies targeted more than one risk factor (range 1 to 8). Overall, interventions were associated with mixed effects among risk factors, showing positive and/or neutral effects, often across multiple measures (Tables 1 and 2). No interventions were associated with negative effects on risk factors. The sustained effect of the intervention was

evaluated in 13 studies with multiple follow-ups, the follow-up time ranging from 3 months to 3.6 years.[25] The effect of behavioral change interventions was most frequently measured and reported as changes in physical activity and blood pressure (Figure 2). No studies evaluated sleep as an outcome.

Physical activity was reported using various measures, including the number of steps, change in sedentary behavior, and self-reported physical activity. Among the 46 interventions evaluating changes in physical activity, improvements were observed for 14 interventions, and no changes were reported for 21 interventions (Supplementary Table S1). In the 12 studies where improvements were reported, BCTs were used in 83% of studies (Table 2). Seven studies reported long-term effects of the intervention on physical activity, with two interventions associated with sustained benefits. Both these interventions were delivered by a multidisciplinary team using a face-to-face approach (Table 2).[25,26]

Changes in blood pressure were measured using systolic and/or diastolic blood pressure (mmHg), and combined systolic/diastolic values. Of the studies evaluating blood pressure, 12/38 (13%) were associated with improvements (Supplementary Table S1). Interventions delivered by multidisciplinary teams were more likely to be associated with improved blood pressure (Table 2), however, only two of these interventions reported using BCTs. Six studies reported mixed-effects between systolic and diastolic blood pressure control, and twenty-eight interventions were associated with no changes. Three studies reported sustained benefits of

the intervention (i.e., continued blood pressure reduction) at 3, 6 and 12 months.[25,27,28] These interventions were primarily face-to-face, with one intervention also including a telephone follow-up (Table 2). However, three other studies reported a loss of benefit, with the initial reductions in blood pressure lost at follow-up.[29,30]

Changes in weight among participants were measured using body mass index (BMI), waist circumference, and body weight. Twenty-nine studies investigated weight change, with five reporting improvements in weight measures (Supplementary Table S1). Among these five studies, four used different BCTs, and three were delivered by multidisciplinary teams. One intervention (developed using TTM) was associated with improved weight (Table 2).[20] Of the four studies assessing long-term effects, none provided evidence of sustained effects.[25,30-32]

Changes in blood cholesterol were measured using total blood cholesterol, low-density lipoprotein (LDL), high-density lipoprotein (HDL), and non-HDL levels in 29 studies. Blood cholesterol was improved in five studies, ten reported mixed effects, while 14 studies reported no change in blood cholesterol (Supplementary Table S1). BCTs (e.g., motivational counselling) were used in four interventions that reported positive changes in blood cholesterol (Table 2). However, the impact of BCTs on blood cholesterol is unclear, as similar BCTs resulted in no change from baseline in other studies. Of the four studies assessing long-term effects, no changes were observed in blood cholesterol.

Changes in diet were self-reported by participants using validated surveys of diet quality (e.g., Australian Recommended Food Score), and self-reported nutritional intake (e.g., fruit and vegetables). Of the 25 studies which investigated dietary changes, 11 reported improvements, and two reported mixed effects (Supplementary Table S1). Among the 11 that reported improvements, nine used BCTs (e.g., goal setting), and three used the TTM and self-care model (Table 2). Follow-up data for changes in diet were assessed in five studies, with sustained effects for improved diet reported in two studies, one at 3 and the other at 12 months.[31,32]

Smoking cessation was self-reported by participants, and was improved in six of 24 studies. Two studies reported mixed effects, with positive changes in smoking cessation rates, but no effect on smoking relapse and motivation to quit (Supplementary Table S1).[33] The sustained effects of the intervention were measured in two studies. An improvement in smoking cessation was reported in one study six months after the intervention, featuring risk factor-targeted counselling.[31] In contrast, the other study showed no change one year after the intervention, which was based on a structured support program.[25]

Changes in alcohol consumption were assessed in 14 studies, and improvements were reported in three studies (Supplementary Table S1), where the intervention was provided by a multidisciplinary team (Table 2). One study assessed the sustained effect on behavioral

change regarding alcohol consumption and there was no change immediately after the intervention, but a positive change was observed at follow-up six months later.[31]

Changes in blood glucose were reported using fasting blood glucose and glycated hemoglobin. Changes in blood glucose were observed for 14 interventions, including two studies with multiple time assessments (Table 1, Supplementary Table S1). Improvements in blood glucose were observed in three studies, with these interventions delivered by a multidisciplinary team (Table 2).[34-36] However, there were no sustained effects or improvements in two studies that had follow-up data.

Discussion

In this scoping review, we provide a summary of the current literature on the effect of behavior change interventions on cardiovascular risk factors. We have highlighted the lack of clarity in the use of lifestyle behavior change interventions for the secondary prevention of stroke. Our findings indicate variability in the use and reporting of validated theoretical frameworks when developing interventions. While intervention effects were mixed, some improvements in risk factors were observed, most commonly associated with interventions that included behavior change techniques and were delivered by a multidisciplinary team. Moreover, we did not find evidence reporting the effects of a behavioral change intervention on sleep. The latter finding is likely due to its recent addition as one of the Life's Essential 8 risk factors.

The majority of the interventions combined face-to-face programs with technology (e.g., smartphone applications) to improve delivery of the program. The increase in use of technology has been leveraged to facilitate the delivery of programs to the patient at home and promote self-management, rather than relying solely on clinician support. Use of technology to deliver care has previously been associated with improved lifestyle behaviors relevant to secondary prevention, including medication adherence,[37-40] and physical activity.[41] Combining face-to-face and technology modalities may be used to better promote behavior change and manage risk factors.[42,43]

In over a third of included studies, the authors had clearly stated the theoretical framework used to inform development of the intervention. It is crucial that theoretical frameworks are used when developing interventions to promote behavior change, given the evidence strongly supports increased effectiveness.[44,45] A wide range of behavior change techniques were employed in the interventions. The most commonly used methods were motivational interviewing, goal setting, self-monitoring, and counselling, all of which were associated with positive behavior change.[46,47] These techniques were often combined and tailored to individual participant needs, with the aim of supporting specific behaviors to improve risk factors (e.g., increase physical activity), which may improve effectiveness.[45] However, in many studies the authors did not clearly define or describe the behavior change techniques used. Due to the mixed effects, and lack of reporting in the studies, it is difficult to highlight which techniques are most effective and appropriate to improve risk factor control among

people living with stroke or TIA. In order to improve clarity, and potentially effectiveness, development of future interventions should adopt and report on the relevant behavior change taxonomy. [22] In doing so, the most effective theories and techniques could be identified and used to improve secondary prevention of stroke.

Another important aspect highlighted in this review is the role of caregivers in supporting behavior change. Approximately one-third of the studies mentioned the inclusion of other participants, such as family caregivers,[19] or friends,[48] to support the patient's behavior change efforts. This inclusion underscores the importance of a supportive environment and social support for achieving and maintaining behavior change, particularly during stroke recovery. However, none of these studies explicitly addressed the contribution of caregivers in the interventions. Previous research in patients with heart failure has indicated that targeting dyads (i.e., the patient and caregiver), rather than the patient alone, can effectively improve disease management and lead to improved outcomes for both parties.[49] Accordingly, future research investigating behavior change among people living with stroke or TIA should also consider including caregivers in the intervention.

Changes in the cardiovascular risk factors included in this review varied, showing mixed or neutral effects. This variability was observed regardless of the intervention mode of delivery, the proximity of intervention sites, the provider, the duration of intervention, or the number of risk factors targeted. A substantial number of interventions showed mixed effects within

various measures used for each risk factor (69%), which makes it difficult to draw conclusions regarding risk factor control. For example, some interventions targeting physical activity reported increased daily step count but no change in sitting time. This variability suggests that the effectiveness of interventions may depend on several factors such as the type and delivery of the intervention, the modalities used, and the theoretical framework informing the intervention. While this review was focused on the effect of lifestyle behavior change interventions on cardiovascular risk factor outcomes, further work is required to understand how these can also be used to promote adherence to medication among the stroke population. A previous review of self-management strategies among this cohort highlighted a need for improvement in this area, which would lead to improved health outcomes when implemented alongside uptake of other healthy lifestyle behaviors.

The sustained effects measured in a subset of studies are of particular interest. When behavior change interventions are successful, they can have lasting impacts on various risk factors, and overall health.[50] However, in this review, we found few studies that measured sustained effects and had improvement in risk factors (18%), with few shared features that allowed the identification of the most effective strategies for sustained benefit. As such, further research incorporating longer follow-up periods is required to identify the characteristics of effective interventions and the factors that contribute to long-term maintenance. Indeed, stroke is a complex condition, requiring long-term management and some interventions might also cause harm and regular follow-up is important to sustain the intervention effects.[51] While we could

not identify evidence for an overall approach that proved superior for promoting and sustaining lifestyle behavior change, a consistent and important feature among the interventions was personalization to the participant. Personalization allows care to be delivered in the context of a patient, rather than using a one-size-fits all, which can improve adherence to treatment,[52] and effectiveness in management of cardiovascular disease.[53]

Strength and limitations

This scoping review used a systematic search strategy and pre-published protocol to capture the most current literature regarding the effectiveness of lifestyle behavioral change on nine cardiovascular risk factors associated with stroke. We highlighted the variability and lack of transparency in reporting the use of evidence-based frameworks and the role of the caregiver, and discuss the importance of maximizing the potential effectiveness of these interventions. However, we were unable to find evidence for the effects of behavioral change interventions on sleep health, and as such are unable to provide a summary of the literature regarding this emerging risk factor. While we assessed the effects of the interventions on traditional risk factors known to be associated with stroke recurrence, we did not include information regarding further novel or emerging risk factors (e.g., anxiety or depression) *and the influence of social and environmental factors on the uptake of health behaviors*. Additionally, we could not evaluate the intervention effects through an equity, diversity, and inclusion lens, such as the inclusion of sexual and gender minorities, people from culturally and linguistically diverse

287 communities, and those with low socioeconomic status or education level since that

288 information was not consistently available in the articles.

Conclusion

We observed mixed findings on effectiveness of behavior change interventions that support lifestyle change in people living with stroke or TIA. There is large variability in the use of behavior change theories and techniques, which produced varied results in risk factor management for the secondary prevention of stroke. It is vital that the development of future interventions considers the use of evidence-based behavior change theories, the most appropriate modality to deliver the intervention, and the potential inclusion of caregivers. Further research is needed to understand the most effective methods to promoting behavior change that can be sustained over long periods of time to support the lifelong process required for secondary prevention of stroke, particularly among underserved populations. It is important that future research include these populations, and authors report these cohort characteristics. Consideration of emerging and novel risk factors such as sleep as outcomes of interest are also warranted.

Funding

No specific funding was obtained for this review. LB is the recipient of a National Natural Science Foundation of China grant (72104221), and scholarships from the Postdoctoral Research Foundation of China (2023M743197), and China Scholarship Council (202307040053). DAC and AB acknowledge fellowship support from the National Health Medical Research Council of Australia (1154273; 1198006). MFK acknowledges fellowship support from the National Heart Foundation of Australia (105737).

Disclosures

None.

Data availability: The data underlying this article and the detailed search strategies will be shared on reasonable request to the corresponding author (LB).

Supplemental Material

Supplemental File S1. PRISMA Checklist.

Supplemental Table S1. Intervention effects on risk factor outcomes.

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Tables and Figures

Table 1. Characteristics of included studies (N = 73).

Author, Year	Participants	Sample, Women (%)	Theoretical Framework	Behavior Change Techniques	Intervention (provider, modality, duration)	Risk Factor Outcomes (positive and/or neutral)
Mackenzie et al, 2013[37]	Stroke or TIA, Hypertension, >18 years	56, (32)	Not reported	Motivational interviewing	Nurse Phone 6 months	BP (n)
Boden-Albala et al, 2019[54]	Mild-to-moderate stroke or TIA, >18 years	478, (51)	Not reported	Reminders	Multidisciplinary team face-to-face + phone 12 months	BP (n)
Kamal et al, 2015[55]	Stroke, >18 years, >1m from index event	162, (32)	Not reported	SMS; reminders; Compensation	Multidisciplinary team Phone 2 months	BP (n)
Kerry et al, 2013[56]	Stroke or TIA, <9m from index event	237, (43)	Not reported	Not reported	Nurse Phone 12 months	BP (n)
Owolabi et al, 2019[57]	Stroke, >18 years, <1y from index event	400, (37)	Not reported	Customized report card; SMS; Educational video	Physician face-to-face + phone 12 months	BP (n)
Sarfo et al, 2018[58]	Stroke, >18 years, <1m from index event	56, (35)	SDT	Motivational interviewing; self-care model; Motivational text messages	Multidisciplinary team face-to-face + phone 3 months	BP (n)
Kringle et al, 2020[59]	Stroke, >18 years, 6m-5y from index event, within 50 miles	21, (62)	Not reported	Self-care model; Feedback; Problem solving	Occupational therapist face-to-face + phone 4 weeks	PA (n)

Author, Year	Participants	Sample, Women (%)	Theoretical Framework	Behavior Change Techniques	Intervention (provider, modality, duration)	Risk Factor Outcomes (positive and/or neutral)
Vanroy et al, 2019[48]	Stroke, <80 years, 3w-10w from index event	53, not reported	TTM; SDT	Motivational interviewing; goal setting; self-care model; Barrier identify, Increasing autonomy; Social support	Physical therapist internet 12 months	PA (n)
Ashizawa et al, 2021[60]	Minor stroke or TIA, >50 years	33, (42)	Not reported	Cues; Planned time schedule; Encouragement	Researcher face-to-face + phone 3 months	PA (n)
English et al, 2016[61]	Stroke, >6m from index event	33, (37)	Not reported	Motivational interviewing; Encouragement; Feedback	Researcher face-to-face + phone 7 weeks	PA (n)
Moren et al, 2016[62]	TIA	56, (53)	Not reported	Motivational interviewing; Teach back	Physical therapist face-to-face 6 months	PA (n)
Grau-Pellicer et al, 2020[63]	Stroke, >18 years	41, (49)	Not reported	Feedback	Physical therapist internet 2 months	PA (+)
Ashizawa et al, 2022[24]	Minor ischemic stroke or TIA, >50 years	52, (34)	Not reported	Goal setting; Self-care model; Feedback	Not clear face-to-face + phone 3 months	PA (+, n)
Mansfield et al, 2016[64]	Stroke, within 50 km	26, (42)	TTM; SCT	Not reported	Multidisciplinary team face-to-face 6 weeks	PA (+, n)
Orme et al, 2020[65]	Mild to moderate stroke or TIA, >18 years	24, (42)	Not reported	Goal setting	Multidisciplinary team face-to-face 6 weeks	PA (+, n)

Author, Year	Participants	Sample, Women (%)	Theoretical Framework	Behavior Change Techniques	Intervention (provider, modality, duration)	Risk Factor Outcomes (positive and/or neutral)
Ifejika et al, 2020[66]	Minor stroke or TIA, 18-85 years	25, (44)	Not reported	Goal setting; Self-care model; Feedback	Researcher Phone + internet 3 months	Weight (n)
Nir et al, 2004[67]	Stroke	155, (48)	Self-care model	Goal setting	Students(nurse) face-to-face 12 weeks	Diet (+)
Sauerbeck et al, 2005[68]	Stroke, >18 years, within 50 miles	405, (6)	Not reported	Not reported	Nurse phone 3 months	Smoking cessation (+)
Hornnes et al, 2014[33]	Stroke or TIA	128, (4)	BCT	Motivational interviewing	Nurse face-to-face + phone 10 months	Smoking cessation (+, n)
Kim et al, 2020[69]	Stroke, >19 years	99, not reported	Not reported	Self-care model; Feedback	Clinicians App + internet 12 weeks	BP (+), Weight (-)
Holzemer et al, 2011[70]	Ischemic stroke or TIA, 18-89 years	27, not reported	SDT	Encouragement Support via phone	Multidisciplinary team phone 3 months	BP (n), BC (+, n)
Kronish et al, 2014[71]	Stroke or TIA, ≥ 40 years, <5y from index event	600, (59)	not reported	Self-management; Problem-solving techniques; Planning; Feedback; Social persuasion	Multidisciplinary team face-to-face 6 weeks	BP (+), Blood cholesterol (n)
Ögren et al, 2018[72]	Stroke or TIA	660, (41)	not reported	Motivational interviewing	Multidisciplinary team phone 36 months	BP (+), Blood cholesterol (+)
Irewall et al, 2015[73]	Stroke or TIA	484, (43)	not reported	Motivational interviewing	Multidisciplinary team phone	BP (+, n), Blood cholesterol (+)

Author, Year	Participants	Sample, Women (%)	Theoretical Framework	Behavior Change Techniques	Intervention (provider, modality, duration)	Risk Factor Outcomes (positive and/or neutral)
					12 months	
Feng et al, 2021[74]	Stroke, >60 years	120, (47)	not reported	Not reported	Multidisciplinary team face-to-face + phone 3 months	Diet (+), Physical activity (+)
Marquardt et al, 2017[20]	Stroke	76, (56)	TTM	Mental Contrasting; Implementation intentions; Self-regulation strategy; Goal commitment and implementation	Interventionists face-to-face 3 weeks	Physical activity (+, n), Weight (+)
Gillham et al, 2010[75]	Minor stroke or TIA	50, (3)	TTM	Motivational interviewing	Researcher face-to-face + phone 6 weeks	Physical activity (+), Diet (+), Alcohol consumption (n)
Paul et al, 2016[76]	Stroke	23, (52)	CT	Goal setting; Self-care model; Planning; Feedback	Researcher face-to-face + App 6 weeks	Physical activity (+, n), BP (n), Weight (n)
Wolfe et al, 2010[77]	Stroke, <6m from index event	520, (48)	not reported	Not reported	Researcher face-to-face 8 months	Smoking cessation (n), Alcohol consumption (n)
Green et al, 2007[78]	Stroke	164, (42)	TTM	Motivational interviewing; Goal setting	Multidisciplinary team face-to-face + phone within 1-2 months	Smoking cessation (n), Diet (n), Physical activity (n),

Author, Year	Participants	Sample, Women (%)	Theoretical Framework	Behavior Change Techniques	Intervention (provider, modality, duration)	Risk Factor Outcomes (positive and/or neutral)
						Weight (n)
Rimmer et al, 2000[17]	Stroke, 30-70 years, ≥6m from index event, 1h commute	35, (74)	TTM	Goal setting	Multidisciplinary team Internet 12 weeks	Blood cholesterol (+, n), Diet (n), Physical activity (n)
Hunter et al, 2023[79]	Mild stroke or TIA, >18 years, >4m from index event, live close	37, (27)	Not reported	Not reported	Multidisciplinary team face-to-face + internet 12 weeks	BP (n), Weight (n), Physical activity (n)
Rimmer et al, 2009[80]	Stroke, >18 years, >6m from index event	41, (6)	Not reported	Not reported	Multidisciplinary team face-to-face 14 weeks	BP (+, n), Blood cholesterol (+, n), Weight (n)
Heron et al, 2019[81]	Minor stroke or TIA, >4w from index event	39, (4)	Not reported	Motivational interviewing; '5 As' approach; Feedback	Nurse & GP face-to-face + phone 12 weeks	BP (+), Weight (+), Diet (+), Physical activity (+)
Joubert et al, 2020[82]	Stroke, <3m from index event	158, (5)	Not reported	Goal setting; Feedback; review of behavior goals; Encouragement.	Multidisciplinary team face-to-face + phone 12 months	BP (n), Blood cholesterol (+, n), Blood glucose (n), Weight (+)
Olaiya et al, 2017[34]	Stroke or TIA, >18 years, within 50 km	463, (36)	Not reported	Goal setting; Barrier identify; Benefits of change	Multidisciplinary team face-to-face + phone 18 months	BP (n), Blood cholesterol (+, n), Weight (n),

Author, Year	Participants	Sample, Women (%)	Theoretical Framework	Behavior Change Techniques	Intervention (provider, modality, duration)	Risk Factor Outcomes (positive and/or neutral)
						Blood glucose (+)
Adie et al, 2010[83]	Stroke or TIA, >18 years, <1m from index event	56, (54)	SCT	Motivational interviewing; Goal setting; Feedback	Researcher & GP phone 4 months	BP (n), Weight (n), Blood cholesterol (n), Physical activity (n)
Lennon et al, 2008[84]	Ischemic stroke or TIA, >18 years, >1y from index event	46, (42)	Not reported	Not reported	Physical therapist face-to-face 10 weeks	Weight (n), BP (n), Physical activity (n), Blood cholesterol (n)
Kirk et al, 2014[85]	Minor stroke or TIA, >18 years	24, (21)	Not reported	Not reported	Multidisciplinary team face-to-face 5 months	Blood cholesterol (n), Blood glucose (n), BP (n), Weight (n), Physical activity (n), Diet (+)
Kim et al, 2013[86]	Ischemic stroke, <1y from index event	36, (36)	Not reported	Feedback	Research assistant Internet + phone + video 9 weeks	Blood cholesterol (n), Physical activity (+), Smoking cessation (n), Alcohol consumption (n), Diet (+)
Allen et al, 2009[87]	Ischemic stroke, discharge <8w from	319, (5)	Not reported	Not reported	Multidisciplinary team face-to-face + phone	BP (n), Blood cholesterol (n),

Author, Year	Participants	Sample, Women (%)	Theoretical Framework	Behavior Change Techniques	Intervention (provider, modality, duration)	Risk Factor Outcomes (positive and/or neutral)
	index event, within 25 miles				6 months	Smoking cessation (n), Alcohol consumption (n), Physical activity (n)
McManus et al, 2009[88]	Stroke or TIA, <3m from index event	205, (53)	Not reported	Not reported	Nurse face-to-face 3 months	BP (n), Blood cholesterol (n), Smoking cessation (n), Blood glucose (n)
Prior et al, 2011[89]	Mild stroke or TIA, <12m from index event	80, (49)	Not reported	Not reported	Multidisciplinary team Phone + internet 6 months	BP (n), Blood cholesterol (+, n) Blood glucose (n), Weight (+), Physical activity (+)
Leistner et al, 2012[90]	Minor stroke or TIA, >18 years	364, (37)	Not reported	Motivational interviewing; Self-care model; Group support; Individual counseling	Multidisciplinary team face-to-face 6 months	BP (+), Blood cholesterol (n), Smoking cessation (+), Physical activity (+)
Kono et al, 2013[91]	Ischemic stroke or TIA	70, (32)	Not reported	Goal setting, Self-care model; Counseling on behavioral changes	Health care professional face-to-face 6 months	BP (+), Blood cholesterol (+, n), Physical activity (+, n), Diet (+),

Author, Year	Participants	Sample, Women (%)	Theoretical Framework	Behavior Change Techniques	Intervention (provider, modality, duration)	Risk Factor Outcomes (positive and/or neutral)
						Weight (n)
Wong et al, 2023[92]	Stroke, >18 years	54, (5)	HBM; Reflection and Refractive theories	Barrier identify; Self-care model	Dietitian face-to-face 3 months	BP (+, n), Weight (+, n), Diet (+, n), Physical activity (+), Smoking cessation (+)
Guillaumier et al, 2022[93]	Stroke or TIA, >18 years	256, (35)	BCT	Goal setting; Feedback	Researcher internet 12 weeks	Diet (n), Smoking cessation (n), Alcohol consumption (n), Physical activity (n)
Eames et al, 2014[94]	Stroke or TIA	66, (47)	Not reported	Not reported	Health care professional face-to-face + phone 3 months	Diet (n), Weight (n), Physical activity (n), Alcohol consumption (n), Smoking cessation (n)
Wan et al, 2016[39]	Ischemic stroke or TIA, >35 years, >1m from index event	80, (29)	Not reported	Goal setting; Encouragement; Barrier identify;	Nurse phone 3 months	Physical activity (n), Diet (n), BP (n), Smoking cessation (n), Alcohol consumption (n)

Author, Year	Participants	Sample, Women (%)	Theoretical Framework	Behavior Change Techniques	Intervention (provider, modality, duration)	Risk Factor Outcomes (positive and/or neutral)
Fruhwirth et al, 2022[95]	Ischemic stroke, 18-55 years	42, (38)	Psychological theories	Goal setting, Self-care model; Feedback	Stroke physicians App 3 months	PA (+), Alcohol consumption (+), Diet (n), Smoking cessation (n), BP (n), Weight (n)
Driver et al, 2023[96]	Stroke, 18-85 years, >12m from index event	57, (54)	SCT; HBM	Goal setting, Self-care model; Identification of behavioral cues	Coach interventionists face-to-face + internet 12 months	Weight (+, n), Blood cholesterol (+, n), BP (n), Blood glucose (n), Physical activity (n), Diet (n)
Brouwer-Goossensen et al, 2022[97]	Ischemic stroke or TIA, >18 years	92, (37)	Not reported	Motivational interviewing	Nurse face-to-face 3 months	Smoking cessation (n), Physical activity (n), Diet (n), Weight (n), BP (n), Blood cholesterol (n), Blood glucose (n)
Towfighi et al, 2020[98]	Stroke or TIA, >40 years, <3m from index event	100, (38)	Lifestyle Redesign theory	Goal setting; Sharing	Occupational therapist face-to-face 6 weeks	Weight (n), Diet (n), Physical activity (n), Smoking cessation (n), BP (n),

Author, Year	Participants	Sample, Women (%)	Theoretical Framework	Behavior Change Techniques	Intervention (provider, modality, duration)	Risk Factor Outcomes (positive and/or neutral)
						Blood cholesterol (n), Blood glucose (n)
Joubert et al, 2009[99]	Stroke or TIA	186, (45)	Not reported	Goal setting; Feedback	Multidisciplinary team face-to-face + phone 12 months	BP (+, n), Blood cholesterol (n), Weight (+), Physical activity (+), Smoking cessation (n), Alcohol consumption (n)
Towfighi et al, 2021[100]	Stroke or TIA, >40 years, <3m from index event	487, (35)	HBM	Goal setting	Multidisciplinary team Phone + internet 12 months	BP (n), Blood cholesterol (n), Blood glucose (n), Weight (n), Physical activity (n), Diet (+, n), Smoking cessation (n)
SPRINT INDIA trial collaborators, 2023[101]	Stroke, >18 years, 2d-3m from index event	3678, (27)	Not reported	Not reported	Multidisciplinary team Phone + internet 12 months	BP (n), Weight (n), Blood glucose (n), Blood cholesterol (n), Physical activity (n), Alcohol consumption (+),

Author, Year	Participants	Sample, Women (%)	Theoretical Framework	Behavior Change Techniques	Intervention (provider, modality, duration)	Risk Factor Outcomes (positive and/or neutral)
						Smoking cessation (+)
Cheng et al, 2018*,[102]	Ischemic stroke or TIA, <3m from index event	404, (40)	CCM	Not reported	Multidisciplinary team face-to-face + phone 12 months	3m: BC (+), BP (n), Smoking cessation (n), Physical activity (n) 12m: Blood cholesterol (+) BP (n), Smoking cessation (n), Physical activity (n)
Sylaja et al, 2021*,[103]	Stroke or TIA, >18 years	234, (30)	Not reported	Not reported	Multidisciplinary team face-to-face 6 months	3m: BP (+), Blood glucose (+), Smoking cessation (n), Alcohol consumption (n) 6m: BP (+), Blood glucose (+), Smoking cessation (n), Alcohol consumption (n)
Sit et al, 2007*,[104]	Minorr stroke or TIA, >18 years	190, (44)	Not reported	Goal setting; Action plans; Feedback; Experience sharing	Nurse face-to-face 2 months	1w: BP (+), Physical activity (n), Diet (n), Smoking cessation (n),

Author, Year	Participants	Sample, Women (%)	Theoretical Framework	Behavior Change Techniques	Intervention (provider, modality, duration)	Risk Factor Outcomes (positive and/or neutral)
						Alcohol consumption (n) 3m: BP (n), Physical activity (+), Diet (n), Smoking cessation (n), Alcohol consumption (n)
Teuschl et al, 2017*,[36]	Ischemic stroke, 40-80 years	167, (27)	not reported	Goal setting, Self-care model;	Multidisciplinary team face-to-face + phone 24 months	12m: Diet (+,n), Alcohol consumption (+), Physical activity (+), Smoking cessation (+), Weight (n), BP (+), Blood cholesterol (+), Blood glucose (+) 24m: Diet (n), Alcohol consumption (+), Physical activity (+), Smoking cessation (+), Weight (n), BP (+), Blood cholesterol (+),

Author, Year	Participants	Sample, Women (%)	Theoretical Framework	Behavior Change Techniques	Intervention (provider, modality, duration)	Risk Factor Outcomes (positive and/or neutral)
						Blood glucose (+)
Sit et al, 2016†,[27]	Stroke	210, (49)	HET	Goal setting, Feedback	Nurse face-to-face + phone 13 weeks	BP (+) 1w: BP (+) 6m: BP (+)
Appalasamy et al, 2020†,[28]	Stroke, >18 years, <6m from index event	177, (34)	HBM	Teach back	Neurologist face-to-face 6 months	BP (+) 12m: BP (+)
Kishita et al, 2023†,[29]	Stroke, 55-75 years	48, (36)	not reported	Self-care model; Feedback	Nurse face-to-face + phone 6 months	BP (+, n) 12m: BP (n)
Nir et al, 2006†,[105]	Stroke, >60 years, within 25 miles	155, (48)	SELF-CARE MODEL	Self-empowerment	Students(nurse) face-to-face 3 months	Diet (+) 6m: Diet (+, n)
Damush et al, 2011†,[106]	Ischemic stroke, >18 years, <1m from index event	63, (2)	SCT; SET	Goal setting; Feedback; Behavioral contracting; Encouragement.	Multidisciplinary team Phone 3 months	Physical activity (n) 6m: Physical activity (n)
Ezeugwu et al, 2018†,[19]	Stroke, >18 years, discharge <2w from index event	33, (44)	SCT	Self-care model; Set targets	Multidisciplinary team face-to-face + phone 2 months	Physical activity (+, n) 4m: Physical activity (+, n)
Ashizawa et al, 2023†,[23]	Minor ischemic stroke or TIA, >50 years	86, (33)	Not reported	Goal setting, Self-care model; Feedback; Education; Telephone intervention	Not clear face-to-face + phone 3 months	Physical activity (+, n) 6m: Physical activity (+, n)

Author, Year	Participants	Sample, Women (%)	Theoretical Framework	Behavior Change Techniques	Intervention (provider, modality, duration)	Risk Factor Outcomes (positive and/or neutral)
White et al, 2013†,[107]	Stroke	31, (24)	Not reported	Goal setting	Multidisciplinary team face-to-face 9 weeks	Weight (n), Diet (+) 3m: Weight (n), Diet (+)
Faulkner et al, 2013†,[30]	Stroke or TIA	60, (49)	HBM	Not reported	Multidisciplinary team face-to-face 2 months	BP (+, n), Blood cholesterol (+, n), Weight (n) 5m: BP (n), Blood cholesterol (+, n), Weight (n)
Sakakibara et al, 2022†,[108]	Stroke, >50 years, >1y from index event	111, (31)	SCT; CT	Motivational interviewing; Goal setting; Feedback; Graded tasks; Problem solving; Action planning; Barrier identify	Lifestyle coach phone 6 months	Physical activity (n), Diet (n), BP (n), Blood glucose (+, n), Blood cholesterol (n) 12m:PA (n), Diet (n), BP (n), Blood glucose (+, n), Blood cholesterol (n)
Ahmadi et al, 2020†,[25]	Stroke, >18 years, <14d from index event, within 20	2072, (34)	not reported	Motivational interviewing; Feedback	Multidisciplinary team face-to-face 24 months	BP (+), Blood cholesterol (+, n), Physical activity (+), Smoking cessation (+),

Author, Year	Participants	Sample, Women (%)	Theoretical Framework	Behavior Change Techniques	Intervention (provider, modality, duration)	Risk Factor Outcomes (positive and/or neutral)
						Weight (n) 1y: BP (+), Blood cholesterol (+), Physical activity (+), Smoking cessation (+), Weight (+) 3y: BP (+), Blood cholesterol (+, n), Physical activity (+), Smoking cessation (n), Weight (n)
Oikarinen et al, 2017†,[31]	Stroke or TIA, 18-65 years	107, (45)	not reported	Lifestyle counselling	Nurse face-to-face 6 months	Physical activity (n), Diet (+), Alcohol consumption (n), Weight (+, n), BP (+), Blood glucose (n), Blood cholesterol (+, n), Smoking cessation (+, n) 3m: Physical activity (n), Diet (+),

Author, Year	Participants	Sample, Women (%)	Theoretical Framework	Behavior Change Techniques	Intervention (provider, modality, duration)	Risk Factor Outcomes (positive and/or neutral)
						Alcohol consumption (n), Weight (+, n), BP (+,n), Blood glucose (n), Blood cholesterol (+, n), Smoking cessation (+) 12m: Physical activity (n), Diet (+), Alcohol consumption (+), Weight (+, n), BP (+, n), Blood glucose (n), Blood cholesterol (+, n), Smoking cessation (+)
English et al, 2024†,[109]	Stroke or TIA, 3m-10y from index event	37, (4)	not reported	Tailored support	Multidisciplinary team internet 6 months	Physical activity group: BP (n), Physical activity (n) 3m: BP (n), Physical activity (+) 12m: BP (n), Physical activity (+)

Author, Year	Participants	Sample, Women (%)	Theoretical Framework	Behavior Change Techniques	Intervention (provider, modality, duration)	Risk Factor Outcomes (positive and/or neutral)
						Diet group: BP (n), Diet (+) 3m: BP (n), Diet (+) 12m: BP (n), Diet (+, n)

Note: *represents studies with assessment during and after the intervention period; †represents studies with multiple assessments in addition to post-intervention assessments; (+), positive change, (n) indicates neutral change; (+,n), mixed effects among various measures of one risk factor (e.g. steps and sedentary behavior for physical activity). BP, blood pressure; SDT, Self-Determination Theory; TTM, Trans-theoretical model; SCT, Social Cognitive Theory; SCM, Self-care model; BCT, Behavior Change Theory; CT, Control theory; HBM, Health Belief Model; CCM, The Chronic Care Model; HET, Health Empowerment Theory; SET, Self-efficacy theory.

Table 2. Features of interventions associated with improved risk factors (N = 73).

Risk factor, (N)	Positive change, n/N, (%)	Features of the interventions				
		Theoretical framework	Behavioral change techniques	Multidisciplinary team	Technology	Duration
Physical activity, (46)	14 (30)	3 (21)	12 (86)	7 (50)	10 (71)	6w-24m
Blood pressure, (46)	12 (26)	2 (17)	11 (92)	6 (50)	5 (42)	3m-36m
Weight, (29)	5 (17)	1 (20)	4 (80)	3 (60)	4 (80)	3w-12m
Blood cholesterol, (29)	5 (17)	1 (20)	4 (80)	5 (100)	5 (100)	6m-36m
Diet, (25)	11 (44)	3 (27)	9 (82)	4 (36)	5 (45)	6w-6m
Smoking cessation, (24)	6 (25)	1 (17)	4 (67)	4 (67)	3 (50)	3m-24m
Alcohol consumption, (14)	3 (21)	1 (33)	2 (67)	2 (67)	3 (100)	3m, 12m, & 24m
Blood glucose, (14)	3 (21)	0 (0)	2 (67)	3 (100)	2 (67)	6m, 18m, & 24m
Sleep, (0)	-	-	-	-		-

Note: The n in parentheses represents number of studies reporting specific risk; m, months; w, weeks.

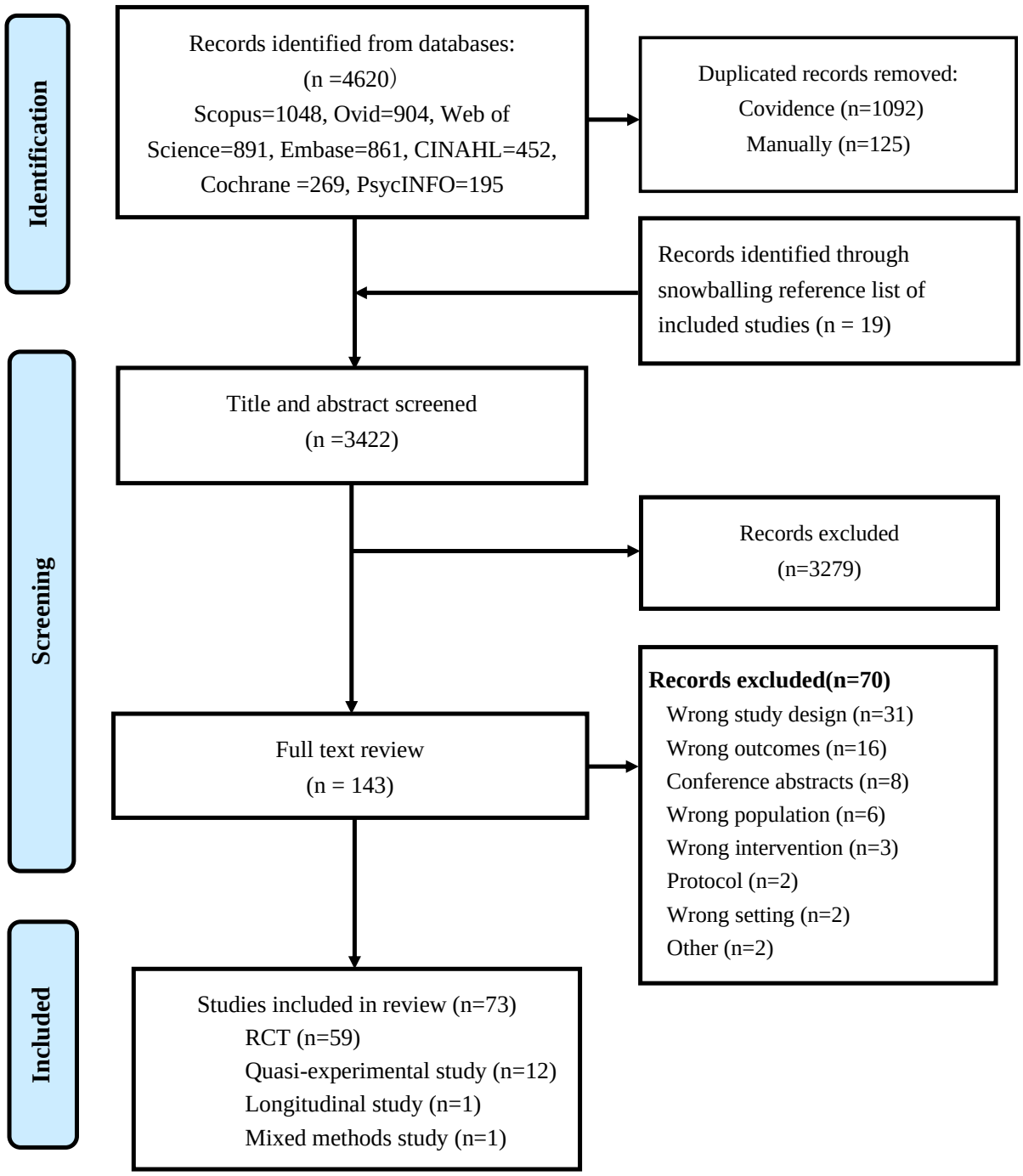

Figure 1. PRISMA flow diagram.

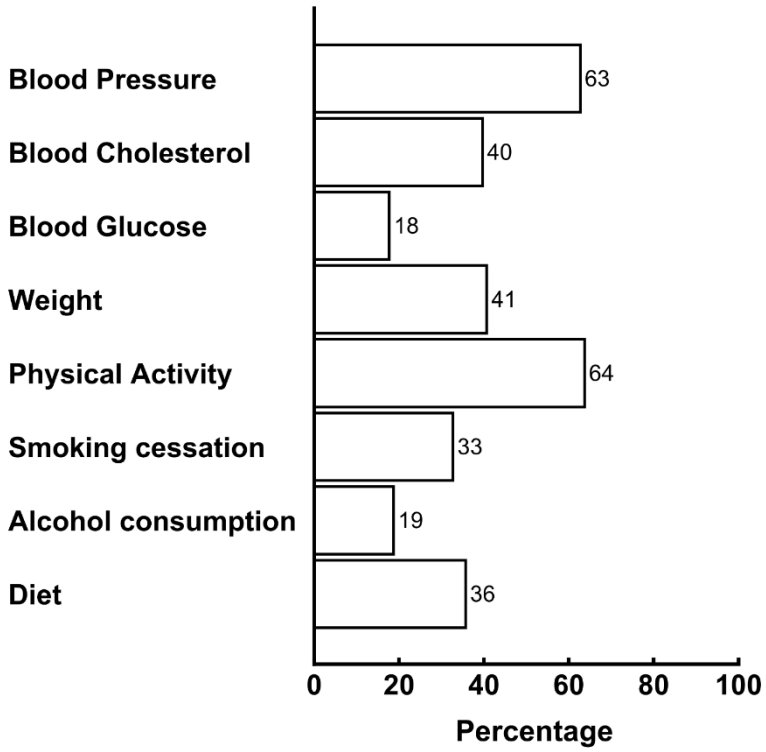

Figure 2. Percentage of risk factor outcomes included in studies (N = 73).