Comparative efficacy and acceptability of resilience-focused interventions for nurses: a systematic review and network meta-analysis of randomized controlled trials

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Abstract

Background The mental health of nurses is deteriorating. Maintaining nurses' resilience has become a focal point for future nursing development.

Objective We aim to rank the effectiveness and acceptability of resilience-focused interventions for nurses.

Methods A systematic review and network meta-analysis were conducted, with comprehensive searches across PubMed, Embase, Cochrane Library, Web of Science, and other databases. Frequentist random-effects network meta-analyses were employed, and RoB-2 was used to assess the quality of evidence.

Results Resilience-focused interventions were found to significantly enhance nurses' resilience (95%CI 0.61, 1.41). Offline field interventions (95%CI 0.64, 1.59) outperformed online interventions (95%CI -0.02, 0.45). Both group (95%CI 0.32, 0.87) and individual (95%CI 0.63, 1.59) interventions showed effectiveness. Anger Management Psychoeducation (95%CI 3.65,7.93, SUCRA = 98.2), Emotional Intelligence training (95%CI 3.32,6.51, SUCRA = 95), and Mindfulness-Based Stress Reduction (95%CI 2.60,5.88, SUCRA = 92.4) were the most effective interventions.

Conclusion Anger Management Psychoeducation, Mindfulness-Based Stress Reduction, and Emotional Intelligence training are the most effective interventions for enhancing nurses' resilience.

International prospective register of systematic reviews CRD42021289477.

Registration of clinical trial and registration identification number Not applicable.

Key points

- Offline field resilience-focused interventions performed better overall in improving nurses' resilience compared to online remote interventions.
- Both group and individual resilience-focused interventions were effective in improving nurses' resilience.
- Anger Management Psychoeducation, Emotional Intelligence training, and Mindfulness-Based Stress Reduction Program were the most promising in improving resilience in nurses.

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Introduction

Since the onset of the COVID-19 pandemic, healthcare workers have been providing intense care to others, sometimes at the cost of their own health. Notably, nurses faced elevated clinical work-related risk posed by the SARS-CoV-2 virus on their psychosomatic well-being during these turbulent times [1]. As researchers stated, the estimated pooled prevalence of moderate depression, anxiety, and post-traumatic stress disorder (PTSD) among nurses has reached 21.7%, 22.1%, and 21.5%, respectively [2, 3], five times the estimated global prevalence of mental symptoms in the normal population (i.e., 4.4% for depression and 3.6% for anxiety disorders, including PTSD) [4]. The presence of mental symptoms not only negatively affect their job performance, leading to decreased workplace safety, but also increases the risk of long-term adverse health consequences (e.g., burnout, secondary traumatic stress, suicide) for nurses [5, 6], resulting in their increased turnover rate. This, in turn, doubles the workload of the in-service nurses, which contributes to the likelihood of developing mental symptoms, resulting in a downward spiral in both nurses' well-being and caring quality. As outlined in the 2023 Magnet® Application Manual [7] and The Future of Nursing 2020–2030: Charting a Path to Achieve Health Equity [8–10], in an era of pandemic and policy shifts, where nurses' workloads are increasing and their health is deteriorating, maintaining nurses' health to ensure that they provide safe, evidence-based, people-oriented care to patients has become a focal point of future nursing development. Mental health is an important component of nurses' health [3]. All these issues called for one thing: enhancing nurses' mental health with effective and targeted intervention programs. The truth is, that fostering resilience in nurses is a promising way to proceed, as advocated by researchers such as Kunzler [11].

Resilience is an important indicator of mental health [12]. A nationwide survey conducted by Mealer et al. [13] reported that only about one-fifth of U.S. nurses were classified as having high resilience. Gillespie et al. [13] found that the resilience levels of Australian clinical nurses were lower than those of the general population. Chen et al. [14] conducted an initial exploration of the resilience levels among 70,932 nurses in China, revealing that Chinese nurses exhibited relatively low resilience. Similarly, Xu et al. [15] discovered that the resilience levels of nurses were significantly lower than those of the general population in China. After decades of development, the definition of resilience remains debated. However, recent conceptualizations have tended to define resilience in terms of "positive outcomes," that is, a result of a complex and dynamic process of adaptation or rapid recovery of mental health during or after stressor exposure, involving the activation of resilience protective factors [11, 16]. Protective factors vary according to individual traits and, overall, refer to "Assets and resources within the individual, their life, and environment that facilitates the capacity for adaptation and 'bouncing back' in the face of adversity" [17]. Currently, the Resilience Protective Factors Checklist (RPFC) categorizes the protective factors of resilience into three categories, individual protective factors (i.e., self-efficacy and internal hope), family protective factors (i.e., having a close relationship with a competent), and community protective factors (i.e., positive support from outside my family, environment safety) [18].

Consistent with the concept, most current training indirectly improves resilience by strengthening its protective factors. For example, most positive psychology-based interventions would enhance one's positive emotions (i.e., one of the protective factors) by learning specific courses, participating in group games, role-playing, and enhancing mobility, which leads to improved resilience. Additionally, the psychotherapies developed based on "Mindfulness " (e.g., Mindfulness-Based Stress Reduction, Mindfulness-Based Cognitive Therapy), improve perception and self-regulation through meditation and yoga, thereby indirectly enhancing resilience. Furthermore, factors such as social support, problem-solving ability, somatic sensation, and emotional venting (e.g., painting) have been targeted in many interventions to obtain positive outcomes indirectly. Nevertheless, due to the similarity of interventions, there are still no guidelines to clearly define the difference between resilience-focused interventions and others. We narrowly define resilience-focused interventions as psychotherapies that are non-pharmacological interventions and non-physical or occupational training, including traditional psychotherapy, modified psychotherapy, innovative psychotherapy, and integrative psychotherapy.

To date, reviews have explored the effectiveness of interventions in improving resilience in nurses, but there are subtle differences from this study in terms of subjects, objectives, and perspectives (see Supplemental Material Table 1). Of these, to our knowledge, only two studies [11, 19] have focused on the effectiveness of resilience-focused interventions in improving nurses' resilience. Zhai et al. [19] examined within-group effect sizes between resilience-focused interventions and no intervention/wait-list groups. They reported moderate to large positive effects on resilience, stress, depression, burnout, and anxiety. In contrast, Kunzler et al. [11]

Table 1 Eligibility criteria for the systematic review

	Inclusion criteria	Exclusion criteria
Population	i. ≥ 18 years. ii. Working in any medical workplace (primary, secondary or tertiary hospitals). iii. Regular employees of medical units. iv. No employment relationship with third parties. v. Irrespective of gender or health status.	i. Nursing students. ii. Nurses who have not been exposed to clinical care for a long time (≥ 1 month; Retired nursing staff). iii. Healthcare givers who are employed by a third party and have direct monetary dealings with the patient/family.
Intervention	i. Any psychological intervention program that includes psychological resilience as an outcome variable (primary, secondary outcome variable). ii. No restrictions on intervention settings, forms of intervention, or theories of intervention.	i. Non-psychological intervention programs with non-mental health-related objectives (e.g., work schedule adjustment, improvement of physical activity, metabolic capacity, etc.). ii. Sole pharmacological (e.g., antidepressant therapy) and physical (exercise) interventions, relaxation techniques, and acupuncture Treatment
Comparator	i. No intervention. ii. Wait-list control. iii. Treatment as usual (TAU). iv. Traditional Mental Health Education. v. Other resilience-focused interventions.	No exclusion criteria
Outcome	Resilience (e.g., using resilience scales such as the Resilience Scale for Adults, Connor-Davidson Resilience Scale)	No exclusion criteria
Study Design	Randomized controlled trials (RCTs), including cluster RCTs, Head-to-head studies.	i. Non-RCTs. ii. Uncontrolled before-after studies.

found very-low certainty evidence of moderate effects in favor of resilience training for nurses' resilience and well-being (≤ 3 months). However, most studies have primarily compared intervention versus control groups, with limited exploration of the relative effectiveness of different types of resilience-focused interventions, which may limit the clinical relevance of the findings [11].

The realization of traditional meta-analysis, a statistical approach that integrates evidence to compare the effectiveness of two types of intervention in dealing with a given problem, requires a directly controlled study of two types of intervention programs. Given the few direct control trials aiming to compare the efficacy of different resilience training, the data requirements of traditional meta-analyses cannot be met. There is an urgent need for a review of indirect comparisons of evidence to provide exploratory recommendations. Network meta-analyses (NMA), developed from traditional meta-analyses, are a methodology that expands from a two-category comparative study of interventions to a simultaneous intercomparison of several different programs. The advantage over traditional meta-analysis is the ability to simultaneously compare indirectly and directly quantitatively the effectiveness and acceptance of multiple interventions for a given problem from different studies, and to rank the effectiveness and acceptance of the intervention to provide the optimal program [20]. Benefiting from this, NMA can compensate for the limitations of traditional meta-analysis, enable comparisons between resilience-focused interventions from different trials, and provide rankings of their effectiveness and acceptability.

As effective resilience interventions for nurses have increased in recent decades, optimizing these interventions remains a key issue both domestically and internationally. Systematic reviews and network meta-analyses will be able to assess the overall effectiveness of resilience-focused interventions in improving nurses' resilience and provide rankings based on their performance in effectiveness and acceptance. This study aims to provide a foundation for resilience-focused interventions by conducting a systematic review and network meta-analysis to examine their effectiveness and acceptability in improving resilience among nurses.

Methods

Protocol and registration

We followed the extension of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement to perform this network meta-analyses [21]. The protocol for this network meta-analysis is registered with the International Prospective Register of Systematic Reviews database (Registration number: CRD42021289477).

Databases and search strategy

We searched the PubMed, Embase, Cochrane Library, Web of Science, EBSCO (CINAHL), CNKI, CBM, Wan Fang, and VIP databases from the date of database inception to July 15, 2023. Following the Population, Interventions, Comparison, Outcome and Study design (PICOS) principle [22], search strategies were constructed as follows: "Resilience, Psychological OR resilience OR mental

toughness OR psychological toughness OR mental elasticity OR psychological elasticity OR restoring force OR resiliency OR resilient OR hardiness OR post-traumatic growth OR flexibility" AND "Nurses OR Nursing OR nurs* OR Healthcare OR caring" AND "randomized controlled trial* OR RCT* OR Clinical Trials, Randomized OR Controlled Clinical Trials, Randomized OR Trials, Randomized Clinical OR Random*". Detailed search strategies were provided in Supplemental Material Table 2.

Eligibility criteria

Eligible RCTs including cluster RCTs, comparing any resilience-focused intervention with resilience measurements (e.g., Connor-Davidson Resilience Scale) against a control group (e.g., no intervention, other interventions, traditional mental education, other resilience-focused interventions) in nurses (i.e., regular employees of medical units, no employment relationship with third parties, aged ≥ 18 years, with no restrictions on the medical workplace) were eligible for inclusion (see Table 1). It should be noted that, due to the similarity of mental health interventions and their mostly positive effects on improving mental health, there are still no guidelines to clearly define the difference between resilience-focused interventions and non-resilience-focused interventions. Given this, we temporarily define resilience-focused interventions narrowly as those that use psychological resilience as a primary or secondary indicator, employing professional psychological methods and techniques to assist individuals or groups in addressing psychological issues, improving mental health, and enhancing adaptive capacity. These interventions include a range of approaches such as cognitive-behavioral therapy, emotional regulation training, and stress management, with the aim of restoring or enhancing psychological functioning. This does not imply, however, that we do not agree with the capacity of other psychological health interventions to improve resilience; the present decision is simply to better reduce statistical heterogeneity and obtain relatively accurate results.

Assessment indicators

Our primary outcomes were efficacy (as measured by the average change in score on the Resilience Measurements from baseline to the end of therapies), all-cause discontinuation (the proportion of nurses who stopped accepting intervention for any reason, which is used as a measure for the acceptability of intervention) [23]. With respect to side effects reported in pharmacotherapy trials, clinicians define acceptability as the sum of efficacy and tolerability in most meta-analyses of drug efficacy networks, with the latter being particularly valued. Yet, side effects are rarely reported in psychotherapy trials, so

the acceptability of resilience-focused training is understood more as efficacy than tolerability [24]. In this case, the acceptability of psychological intervention is perhaps more closely related to the underlying settings such as the form and timing. If resilience was measured using multiple rating scales, we selected the scale with the best psychometric properties and the most consistent usage across studies for inclusion in the trial.

Data extraction

All database results were imported into *EndNote* software and de-duplicated before LMQ and YZP screened and evaluated the titles and abstracts of the studies in the first round of screening. Then, LMQ and YZP independently downloaded and read through the full texts to screen RCTs that met the inclusion criteria. Afterward, LMQ summarized the basic information of the filtered articles into an information extraction table, with the following headers: author, year of publication, country, sample size, setting, design, outcome, time, interventions, comparators, outcome measurements, and available data. Any disagreements were resolved by holding group meetings face-to-face or online to discuss and reach a consensus. When conflicting opinions arose, nursing evidence-based specialists would be invited to engage in a group discussion to resolve differences of opinion based on the study's content and evaluation standards. We employed the following criteria to re-categorize the included interventions: remote interventions delivered via the internet or other multimedia platforms were classified as online remote interventions (e.g., the app '*SUPPORT Coach*' as a self-help tool to reduce trauma-related symptoms), while those requiring face-to-face implementation were categorized as offline field interventions. Interventions explicitly defined as targeting groups were classified as group interventions (e.g., *The New Growth*, which involves skill training and discussions conducted in groups), and all other interventions were classified as individual interventions.

Quality appraisal

The methodological quality of RCTs was evaluated using the revised Cochrane Risk-of-Bias (RoB) tool for randomized trials (RoB-2) [25]. For individually randomized studies, we assessed RoB in five domains:

(i) The randomization process - assessing whether the randomization sequence was generated and implemented appropriately, including the concealment of allocation.

(ii) Deviations from intended interventions - assessing whether the randomization sequence was generated and implemented appropriately, including the concealment of allocation.

Table 2 Characteristics of the included studies

Author (year)	Country	Sample size (IG/CG)	Time points	Measures	CG	IG	Interventions information	
							Duration	Contents
Yu. et al. (2020) [37]	China	40/40	T₀: Baseline, T₁: Post-intervention	CD-RISC	TAU	PPBIP	• Once a week. • Each session lasted 2 h. • Running for 6 weeks.	• Understanding One's Own Emotions (Theoretical lectures + "I See You, You See Me" exercise) • Expression and Understanding of Emotions (Brainstorming + Role-playing + Icebreaker games) • Self-Motivation (Listening to Harvard's Happiness Course + The Power of Mirrors + Preserving Happiness) • Understanding Others' Emotions ("You Speak, I Listen" + Guided tour of hospital departments) • Maintaining Positive Interpersonal Relationships (Managing Stress Secretly + Expressing Gratitude Without Embarrassment)
Huang. et al. (2020) [35]	China	50/50/50	T₀: Baseline, T₁: Post-intervention	CD-RISC	TAU	• PPBIP. PPBIP&PT	• Once a week. • Each session lasted 2 h. • Running for 6 weeks. • The combined training group requires a minimum of one day between intervention sessions.	**IG 1: PPBIP** • "Share Your Story". • Nursing Scenario Drama Performance. • Weekend Mountain Climbing Team Competition. • "My Other Side" Talent Showcase. **IG 2: PT** • **Intervention Format:** Standardized training in basic nursing techniques. • **Content** Standardized training on the following nursing operations, based on the "Fundamentals of Nursing" (6th edition) by People's Medical Publishing House: i. Sterile technique operation. ii. Nasal/oral suctioning technique. ... • **Training Process** i. 30 min of theoretical explanation and demonstration by the instructor. ii. 60 min of hands-on practice. iii. 30 min of evaluation.
Yang. et al. (2021) [43]	China	42/38	T₀: Baseline, T₁: Post-intervention	CD-RISC	TAU	BBIP	• Once a week, 1 h for 8 weeks. • Three 2-hour export lectures. • Intensive courses, 1~1.5 h.	• Setting up a training leadership team. • Selecting activity cases. • Introduction by the group leader. • Case presentation. • Clarifying questions. • Listening to opinions. • Feedback summary.
Lin. et al. (2019) [40]	China	44/46	T₀: Baseline, T₁: Post-intervention	CD-RISC	WCG	MBSR	• 45 min per session. • 6 sessions per week. • Running for 8 weeks. • Flexible adjustment.	• Positive breathing. • Positive meditation. • Body scan.
Li. et al. (2019) [42]	China	40/40	T₀: Baseline, T₁: Post-intervention, T₂: 1 month follow-up	CD-RISC	WCG	SFBT	• Once a week. • Each session lasted 1~1.5 h. • Running for 4 weeks.	• Icebreaker game. • Reviewing the steps of problem solving and learning emotion management theory. • Reviewing the steps of problem solving and emotion management skills. • Reviewing the whole intervention process, rational problem-solving methods, emotion management skills, and effective coping skills.

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Table 2 (continued)

Author (year)	Country	Sample size (IG/CG)	Measures	Time points	CG	IG	Interventions information	
							Duration	Contents
Chesak. et al. (2015) [53]	U.S.A.	19/21	CD-RISC	T_0: Baseline, T_1: 3 months follow-up	TAU	SMART	• Once a week. • Each session lasted 1.5 h. • Running for 4 weeks. • Weekly 1-hour follow-up session.	• Skills to develop intentional attention and reframe life experiences using the five core principles of gratitude, compassion, acceptance, forgiveness, and higher meaning.
Li. et al. (2016) [47]	China	24/24	ERS	T_0: Baseline, T_1: Post-intervention T_2: 3months follow-up	TAU	GPT	• Once a week. • Each session lasted 1.5 h. • Running for 8 weeks.	• Introduce yourself by designing nickname and logo to achieve the purpose of icebreaker. • Use body language and drawing content to express emotions and enhance the interaction between team members. • The group leader guides participants while painting. • Self-exposure through drawing to enhance members' acceptance of others. • Group painting. • Self-acceptance and self-growth through painting.
Grabbe. et al. (2020) [38]	U.S.A.	25/26	CD-RISC	T_0: Baseline, T_1: 1 week follow-up T_2: 3 months follow-up T_3: 12 months follow-up	TAU	CRM	• 3 h.	**Instructors** • The course was taught by two authors, both Certified CRM Teachers trained by the Trauma Resource Institute (TRI) in California. **Course Content** • Instruction and practice of 6 CRM skills: Tracking, Resourcing, Grounding, Gesturing, Shift and Stay, and Help Now! • Activities included identifying "comfort foods," "teach-back" of the brain model, skill stations, and various interactive exercises, such as mindful eating. • Emphasis on the practice of interoception, or "felt-sense," which serves as the foundation for all CRM skills. • Participants had access to the free CRM "ichill" app after the class (option).
Bernburg. et al. (2019) [52]	German	44/42	CD-RISC	T_0: Baseline, T_1: 3 weeks follow-up T_2: 6 months follow-up T_3: 12 months follow-up	TAU	SMACST	• Once a week. • Each session lasted 1.5~2 h. • Running for 12 weeks.	• Work-related stress management training. • Problem solving techniques. • Solution-focused counseling.

Table 2 (continued)

Au-thor (year)	Country	Sample size (IG/CG)	Time points	Measures	CG	IG	Interventions information	
							Duration	**Contents**
Mao et al. (2021) [46]	China	43/45	T_0: Baseline, T_1: Post-intervention	CD-RISC	TAU	EI	**Phase I—System training phase** · Twice a week. · Lasting for one month (Total duration: 7.5 h). **Phase II—Con-solidated learning phase** · Once a week. · Each session lasted 1~1.5 h. · Running for 11 months.	**Phase I** · Educators explained emotional intelligence to the intervention covered themes such as perception of emotions, awareness of emotions, regulation of emotions and practice. **Phase II** · Case discussions.
Sawyer et al. (2021) [54]	U.S.A.	33/42	T_0: Baseline, T_1: 1 month follow-up T_2: 3 months follow-up T_3: 6 months follow-up	BRS	TAU	RISE	· Once a week. · Each session lasted 2 h. · Running for 5 weeks.	Unclear
Hsieh et al. (2020) [39]	Taiwan	49/39	T_0: Baseline, T_1: 6 weeks follow-up	RS	TAU	· BT · SDBT	· Once a week. · Each session lasted 1 h. · Running for 6 weeks.	**SDBT** · Self-guided muscle relaxation. · Diaphragmatic breathing. · Paced breathing, pursed-lips breathing. · Real-time respiratory sinus arrhythmia (RSA) biofeedback. **BT** · Real-time RSA-biofeedback. · Shorter meditation practices.

Table 2 (continued)

Author (year)	Country	Sample size (IG/CG)	Time points	Measures	CG	IG	Interventions information Duration	Contents
van der Meer et al. (2020) [51]	Netherlands	79/105	T$_0$: Baseline, T$_1$: 1 month follow-up	RES	TAU	SUPPORT Coach	• No minimum intervention time requirement. • Individual usage patterns of the App were tracked via a back-office system. The following objective usage data were gathered, • i. Number of times the App was used. • ii. Number of completed self-tests. • iii. Number of performed App exercises. • iv. Time spent in App.	• The 'Information' section. • The 'Find support' section. • The 'Self-test' section. • The 'Calendar' section. • The heart of the app is the 'Manage Symptoms' section: CBT- based exercises (e.g., progressive muscle relaxation, change cognitive perspective, and pleasant events with others).
Zarvijani et al. (2021) [44]	Tehran	33/35	T$_0$: Baseline, T$_1$: 1 month follow-up	AAQ-II	TAU	ACT	• Each session lasted 2 h. • Running for 8 times.	• ACT-based training according to Steven Hayes model, the content of which was unclear. • Conducted by an ACT therapist.
Janzarik et al. (2022) [50]	German	31/33	T$_0$: Baseline, T$_1$: 8 weeks follow-up T$_2$: 3 months follow-up T$_3$: 6 months follow-up T$_3$: 9 months follow-up	BRS	WCG	The new Growth	• Once a week. • Each session lasted 2 h. • Running for 8 weeks.	The training included therapy elements from cognitive behavioral therapy and psychodynamic psychotherapy. • Week 1. The starting point: get to know resilience and understand your problems. • Week 2. On the way to resilience: give up maladaptive behavior and set new goals. • Week 3. The resilient mind control: Train cognitive flexibility and coping skills. • Week 4. Be a good friend to yourself: Train self-care and mindfulness. • Week 5. Be resilient in tough times: Train self-efficacy and self-esteem. • Week 6. Tackle the problem in a resilient way: Use resilience strategies for problem-solving (part 1). • Week 7. From problem analysis to solution design: Use resilience strategies for problem-solving (part 2) • Week 8. The new growth: Reflect on your own development.

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Table 2 (continued)

Author (year)	Country	Sample size (IG/CG)	Time points	Measures	CG	IG	Interventions information Duration	Contents
Sawyer et al. (2023) [49]	U.S.A.	34/34	T_0: Baseline, T_1: 3 months follow-up T_2: 6 months follow-up	BRS	WCG	PGP	• Once a week. • Each session lasted 1.5 h. • Running for 9 weeks.	• **An introduction session.** • **Two resilience sessions**: personal coping resources, oscillation between stress and recovery, post-traumatic growth, and connecting to purpose and meaning. • **Two insight sessions**: cognitive and emotional awareness. • **One self-compassion session**: compassion fatigue and satisfaction, and self-compassion skills. • **Two empowerment sessions**: healthy boundaries, authentic living, and values-behavior alignment. • **A closing session**: synthesis of learning and self-care planning guide. Mindfulness practice serves as a foundation for learning and is infused throughout each session.
Peng. et al. (2020) [55]	China	20/20	T_0: Baseline, T_1: Post-intervention	SCL-90	TAU	RSCI	Unclear.	**Understanding and Assessment** • Understand the family and personal situations. • Assess resilience. • Analyze the sources of negative emotions. **Stress Management and Resilience Enhancement** • Strengthen resilience guidance to alleviate internal pressure. • Improve self-affirmation and recognition. **Cognitive Intervention** • Help nurses establish a correct perception of the work environment, reducing negative emotions. • Enhance responsibility and sense of mission. • Eliminate complaints, fears, and concerns through one-on-one exchanges. **Work Attitude and Emotional Regulation** • Develop a healthy work attitude and encourage a positive mindset. • Increase sense of mission and teach methods for stress relief. • Regulate emotions to improve emotional management.
Yan. et al. (2017) [48]	China	33/32	T_0: Baseline, T_1: 6 months follow-up	CD-RISC	TAU	GMT	• Once a week. • Each session lasted 1.5~2 h. • Running for 10 weeks. • Flexible adjustment.	**Introduction (Week 1)** • Introduce the purpose, content, and basic requirements of Positive Thinking Therapy. **Implementation Phase (Weeks 2–9)** • Weeks 2–4: Body Scanning - Close eyes and scan body from head to toe, focusing on each body part's sensations without judgment. • Weeks 4–5: 12-minute Breathing Space - Sit quietly, focus on breathing, feel airflow, and imagine discomfort melting away with each breath. • Weeks 6–7: Positive Thinking Meditation - Focus attention on body sensations, emotions, and thoughts, accepting them without judgment. • Weeks 8–9: Walking Meditation - Focus attention on the feet and walking sensations. **Conclusion Phase (Week 10)** • Group discussion and exchange on feelings throughout the process and future plans for continuing Positive Thinking training.

Table 2 (continued)

Author (year)	Country	Sample size (IG/CG)	Time points	Measures	CG	IG	Interventions information	
							Duration	**Contents**
Turan. et al. (2020) [45]	Turkey	16/16	T_0: Baseline, T_1: 6 months follow-up	RSA	TAU	AMP	• Once a week. • Each session lasted 1.5 h. • Running for 8 weeks.	• **Session 1**: Orientation. • **Session 2**: The Feeling of Anger and the Relationship between an Event, Thought, and Behavior. • **Session 3**: Automatic Thoughts and Their Effects on Emotions and Behaviors. • **Session 4**: Distinguishing Communication Methods and Recognizing Barriers to Change. • **Session 5**: Communication Methods We Use to Express Ourselves. • **Session 6**: Recognizing Factors that Make Self-Disclosure Difficult and Understanding the Reasons for Inability to Reveal. • **Session 7**: Distinguishing Between Positive and Negative Stress and Reviewing Reasons for Inability to Reveal. • **Session 8**: Writing Thoughts and Feelings About the Psychoeducation Program and Recognizing Achievements from the Sessions.

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Table 2 (continued)

Au-thor (year)	Country	Sample size (IG/CG)	Time points	Measures	CG	IG	Interventions information	
							Duration	Contents
Wang. et al. (2019) [41]	China	30/30	T_0: Baseline, T_1: Post-intervention	CD-RISC	TAU	MBSR	• 6 times a week. • Daily practice time of no less than 45 min. • Running for 8 weeks. • Flexible adjustment.	• Overview of the research content, purpose, and significance. **Implementation Phase** • **Positive Breathing**: Instruct nurses to find a quiet space, close eyes, and deepen breathing to recognize and reduce discomfort. • **Positive Meditation**: Observe thoughts and emotions, experience their creation and disappearance, and objectively accept present psychological feelings. Guide nurses to respond constructively to negative emotions. • **Body Scanning**: Guide nurses to lie down, relax, close eyes, and focus on each body part, experiencing sensations with awareness. Encourage deep breathing to release discomfort.

Table 2 (continued)

Au-thor (year)	Country	Sample size (IG/CG)	Time points	Measures	CG	IG	Interventions information	
							Duration	Contents
Li. et al. (2021) [36]	China	83/90	T_0: Baseline, T_1: Post-intervention	CD-RISC	TAU	PPBIP	• The frequency of intervention varied across the five domains. **Positive Emotions domain** • two on-site lectures in week 1. • daily participation in online activities in week 2. • participation in at least two activities per week in weeks 3 to 4. **Engagement domain** • collection of nurses' interests in the first week. • four activities in weeks 2 to 4. **Interpersonal Relationships domain** • weekly activities in weeks 1 to 3. **Meaningfulness domain** • daily theoretical study of narrative nursing in the week 1 to 6. • one narrative therapy session. **Achievement domain** • one sharing session in week 1. • one-on-one interviews in weeks 2 to 3. • frequency of intervention in weeks 4 to 6.	Program Based on PERMA Model (Martin Seligman's Five Elements of Well-Being): • **Positive Emotion**: Guide nurses to record small happy events. • **Engagement:** Organize reading clubs and long-distance running games based on nurses' interests to promote the experience of flow and happiness. • **Relationships:** Use peer education to encourage nurses to collaborate with peers and enhance social connections. • **Meaning**: Use narrative therapy to help nurses find meaning and value in their lives. • **Fulfillment:** Use role model education, showcasing anti-epidemic personnel, to inspire professional identity, achievement, and heroism, encouraging nurses to learn from these role models.

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Table 2 (continued)

Author (year)	Country	Sample size (IG/CG)	Time points	Measures	CG	IG	Interventions information	
							Duration	Contents

Abbreviations. IG = Intervention Group; CG = Control Group; TAU = Treat as Usual; WCG = Wait-list Control Group; CD-RISC = Connor- Davidson Resilience Scale; RSA = Resilience scale for adults; BRS = Brief Resilience Scale; AAQ-II = Acceptance and action questionnaire; RES = Resilience Evaluation Scale; RS = The Resilience Scale; SCL-90 = The Symptom Check-List-90. SMACKT = Stress Management and Coping Skill Training program, SMART = Stress Management and Resiliency Training program, CRM = Community Resiliency Model, BT = Biofeedback Training interventions, SDBT = Smartphone-delivered Biofeedback Training interventions, PPBIP = Positive Psychology-Based Interventive Program, PPBIP&PT = Professional Training combined with Positive Psychology Intervention, The new Growth = The new Growth Group Therapy, GPT = Group Painting Therapy, SFBT = Solution-Focused Brief Therapy, MBSR-M = Modified Mindfulness-Based Stress Reduction Program, EI = Emotional Intelligence training, RSCI = Resilience Support and Cognitive Intervention, RISE = Resilience, Insight, Self-Compassion, and Empowerment, PGP = Psychoeducational Group Program, AMP = Anger Management Psychoeducation, SUPPORT Coach = SUPPORT Coach APP-based intervention, MBSR = Mindfulness-Based Stress Reduction Program, GMT = Group Mindfulness Therapy, BBIP = Balint-based interventive program, ACT = Acceptance and Commitment Therapy

(iii) Missing outcome data - examining the proportion and handling of missing data and its potential impact on results.

(iv) Measurement of the outcome-assessing whether outcome assessors were blinded and whether outcome measures were appropriate.

(v) Selection of the reported result - evaluating whether the reported results align with a pre-specified analysis plan and whether selective reporting may have occurred.

Each domain was judged as "low risk," "some concerns," or "high risk" of bias, based on the criteria provided in the RoB-2 tool. The overall risk of bias for each study was determined by considering the worst assessment across all domains. Studies with a low risk of bias were given greater weight in the synthesis and interpretation of findings. Studies with some concerns or high risk of bias were included but critically discussed, and their potential impact on the overall results was explored through sensitivity analyses. This approach ensured that the conclusions of the review were robust and not unduly influenced by studies with methodological limitations.

Statistical analysis

Review Manager (RevMan, version 5.3; the Nordic Cochrane Center, the Cochrane Collaboration) [26], Stata version 15.1 [27] and R-4.1.1 software [28] were used to complete all statistical analysis in the NMA [29].

In the pairwise meta-analysis, results can be pooled using either a fixed-effect model or a random-effects model. Which model should we choose? The fixed-effect model assumes a single true effect size across all studies, with variation due only to within-study estimation error [30]. Consequently, larger studies are heavily weighted, as they provide more precise estimates of the same effect, while smaller studies are largely discounted. In contrast, the random-effects model aims to estimate the mean of a distribution of effects, recognizing that each study may reflect a different true effect size. Here, smaller studies are not discounted, as each contributes unique information about the effect distribution. Similarly, larger studies are not overly weighted, as the goal is to avoid undue influence from any single study and instead capture the mean effect across a range of studies. This approach ensures a more balanced and generalizable summary estimate [30].

Suppose an institute conducted several studies to evaluate the effectiveness of a specific intervention in improving resilience among nurses. All studies recruited nurses in the same way, used the same researchers, intensities, and so on, so all are expected to have the identical effect. Furthermore, the researchers aimed solely to determine whether the intervention was effective for

nurses. In this scenario, the fixed-effect model makes sense [30]. The assumption underlying the fixed-effect model is clearly not valid for the current study, as the heterogeneity among the 22 interventions likely has a much greater impact on the results than the commonalities shared across studies (I^2 = 94%). Specifically, the effect of resilience-focused interventions on nurses' resilience may vary due to factors like available resources, work patterns, and experience, which differ across studies. While we lack data to assess these covariates, their existence and impact on effect sizes are logical. The random effects model accounts for such variability, offering greater inclusivity and generalizability, making it the appropriate choice.

Heterogeneity was assessed using the Chi-square (X^2) test and the I^2 statistic. If both $P \geq 0.05$ and $I^2 \leq 50\%$ were satisfied, the studies were considered homogeneous. Otherwise, statistically significant heterogeneity was assumed [31]. Results are presented as standardized mean differences (SMD) with 95% confidence intervals (CIs) for continuous outcomes, and dichotomous outcomes were analyzed by calculating the odds ratios (ORs). A funnel plot was used to assess the potential for publication bias.

In the NMA, we first generated network plots for all comparisons using the STATA software. Second, the outcomes from each trial were combined using a frequentist analysis strategy based on multivariate meta-regression in the Stata Network program after a pairwise meta-analysis for just direct comparisons [29]. Next, the resilience-focused interventions were ranked based on a probability of being the best efficacy and acceptability using surface under a cumulative ranking curve (SUCRA), whose value ranged from 0 to 100%, with values nearer 1 representing higher performance [32, 33]. Considering that the network map of this study did not form a closed loop, consistency between direct and indirect evidence was not assessed [34].

Results

Assessment of included studies
The present study used Endnote 20 as a citation manager to manage the retrieved literature. The search formula was used to retrieve the database to obtain 16489 relevant studies. After eliminating 7878 duplicate studies, 8405 additional studies that did not meet the inclusion criteria were eliminated by censoring titles and abstracts. After full-text evaluation of the remaining studies ($n = 206$), 21 trials were finally included, and they were RCTs published within five years, covering 21 resilience-based interventions. Some researchers have used resilience-focused interventions for individual self-care, including the Positive Psychology-Based Interventive Program (PPBIP) [35–37], Community Resiliency Model (CRM)

[38], among others [39–46]. We also included group interventions, such as Group Painting Therapy (GPT) [47], Group Mindfulness Therapy (GMT) [48], among others [49, 50]. Some researchers have innovatively integrated electronic tools with interventions, developing Smartphone-delivered Biofeedback Training (SDBT) [39] and the 'SUPPORT Coach' app-based intervention [51]. Furthermore, some researchers have combined different targets to construct integrated programs, such as Stress Management and Coping Skill Training program (SMACKT) [52], Stress Management and Resiliency Training program (SMART) [53], Resilience, Insight, Self-Compassion, and Empowerment (RISE) [54], Resilience Support and Cognitive Intervention (RSCI) [55], and Professional Training combined with Positive Psychology Intervention (PPBIP&PT) [35]. In the case of missing data, we counted the demographic characteristics of the included nurses and found that the average age of the nurses was 33.70, and the average length of employment amounted to 8.99. The screening process is described in Fig. 1. Detailed information on the literature characteristics and bias risk for each included study can be found in Table 2; Fig. 2.

Quality appraisal
Among the 21 studies included and assessed by the RoB 2 (see Fig. 2), the highest risks of bias were in domains in measurement of the outcome (Domain 4) and the domain in arising from the randomization process (Domain 1) related to allocation concealment (selection bias), followed by deviations from the intended interventions (Domain 2) related to blinding of participants (information or observation bias), and missing outcome data (Domain 3). Chesak et al. [38, 41, 43, 53] reduced the probability of subject blinding failure by adopting the same form as the intervention group (e.g., both the intervention and control groups used lectures, but the content of the lectures was different, which somewhat reduced bias due to differences in the intervention modes), whereas the other researchers did not provide details of blinding implementation or even used blinding. In fact, due to the nature of interventions, blinding of participants or researchers is extremely difficult or impossible, and therefore we believe that the vast majority of included studies are at risk of varying degrees of performance bias. As for the risk of bias arising from the randomization process domain, both evaluators found that while all of the studies explicitly stated in the text that random sequences were generated for subjects using methods such as computer-generated algorithms. However, with the exception of Swyer et al. [49], who state that the allocation sequence is protected in a password-protected file for a period of time up to the point at which subjects are enrolled in and assigned to the intervention,
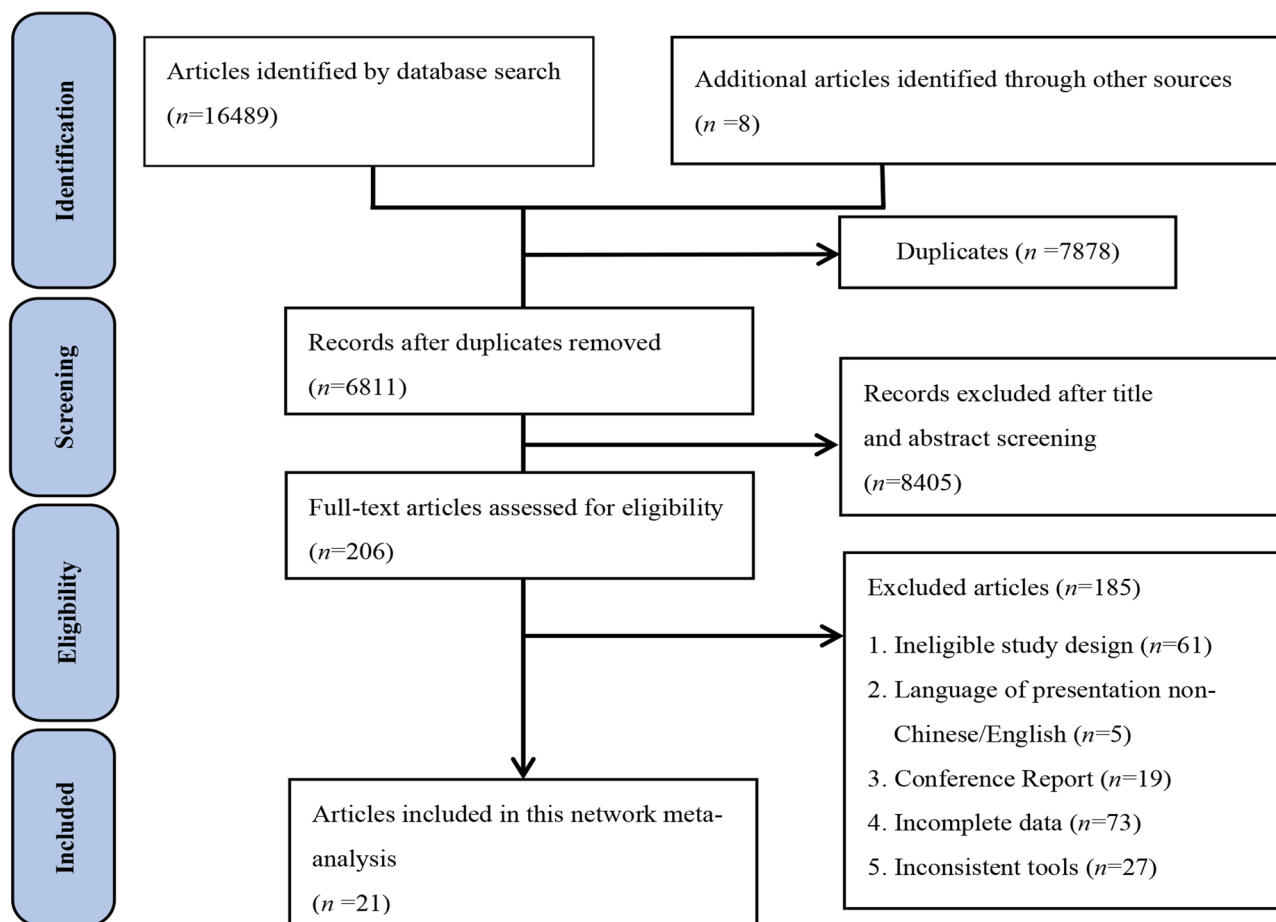
Fig. 1 PRISMA flow diagram. PRISMA 2020 flow diagram presenting the study selection process for the current review. We performed two data search-es, the first of which included PubMed ($n=2084$), Embase ($n=2471$), Cochrane Library ($n=168$), Web of Science ($n=2079$), CINAHL ($n=1417$), CNKI ($n=2179$), CBM ($n=1721$), Wan Fang ($n=1577$), and VIP ($n=628$), from inception of the databases to May 31, 2021. The second search updated the results from June 2021 to June 5th, 2024 in PubMed ($n=192$), Embase ($n=684$), Cochrane Library ($n=627$), Web of Science ($n=511$), CINAHL ($n=98$), CNKI ($n=9$), CBM ($n=21$), Wan Fang ($n=9$), and VIP ($n=2$). A total of 16,489 relevant results were retrieved in both searches

no other study provides specific details about the con-cealment of the implementation of the allocation.

These results can be summarized in Fig. 3, which exhibits the percentage distribution of RoB for domains and overall bias considering the worst assessment for each study. Overall RoB was high in 42.9% of the stud-ies and presented some concerns in 38.1%. Studies with a low or high risk of RoB in the randomization process each accounted for 4.8%, while the remaining 90.5% raised some concerns. RoB in deviations from intended interventions and missing outcome data were low in 71.4%, 85.7% of the studies and presented some con-cerns in 23.8%, 9.5%. In the area of measurement of the outcome, the proportion of low risk versus high risk was essentially equal (52.4% versus 42.9%); and finally, based on the information provided in the included articles, we believe that the researchers made an honest and com-plete report of the study, and fared relatively well in selec-tive reporting.

Pairwise meta-analysis

The forest plot for the results of the pairwise meta-anal-yses is shown in Fig. 4. The results indicated that PPBIP, BT, GPT, SFBT, BBIP, ACT, AMP, MBSR, EI, PGP, and PPBIP&PT were significantly more effective than the control group in improving nurses' resilience, while RSCI was significantly less effective than the control group. Other programs did not demonstrate significant intervention efficacy. Based on the form and content of the interventions, we categorized the 21 interventions into online remote [39, 51] and offline field interven-tions [35, 38–50, 52–55]; group [47–50] and individual interventions [35, 38–46, 51–55]. Based on the form and content of the interventions, we categorized the 21 inter-ventions into online remote interventions and offline field interventions; group interventions and individual interventions. The results showed that online remote interventions performed poorly overall in improving nurses' resilience compared to offline field interventions.

Fig. 2 Risk of bias summary: review authors' judgements about each risk of bias item for each included study (worst-case scenario). With regard to the overall RoB judgement, according to the recommendations in the guidance document, if a study is judged to be at low RoB for all domains for a given outcome, we believe that this study has a low RoB overall for this outcome. If a trial is considered to be high RoB in one domain or to have "some concerns" in multiple domains (three or more) for a given outcome, we believe that it has a high overall RoB for this outcome. If a study is judged to raise some concerns in at least one domain for a given outcome, but not to be at high RoB for any one domain, we believe that it has some concerns
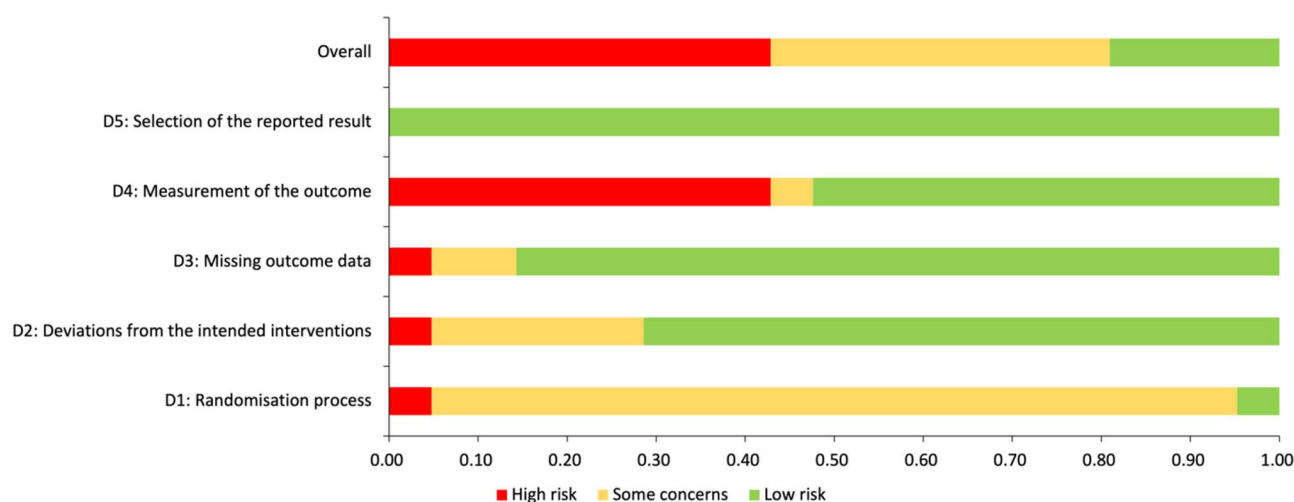
Fig. 3 Percentage distribution of risk of bias in individual studies (RoB 2)
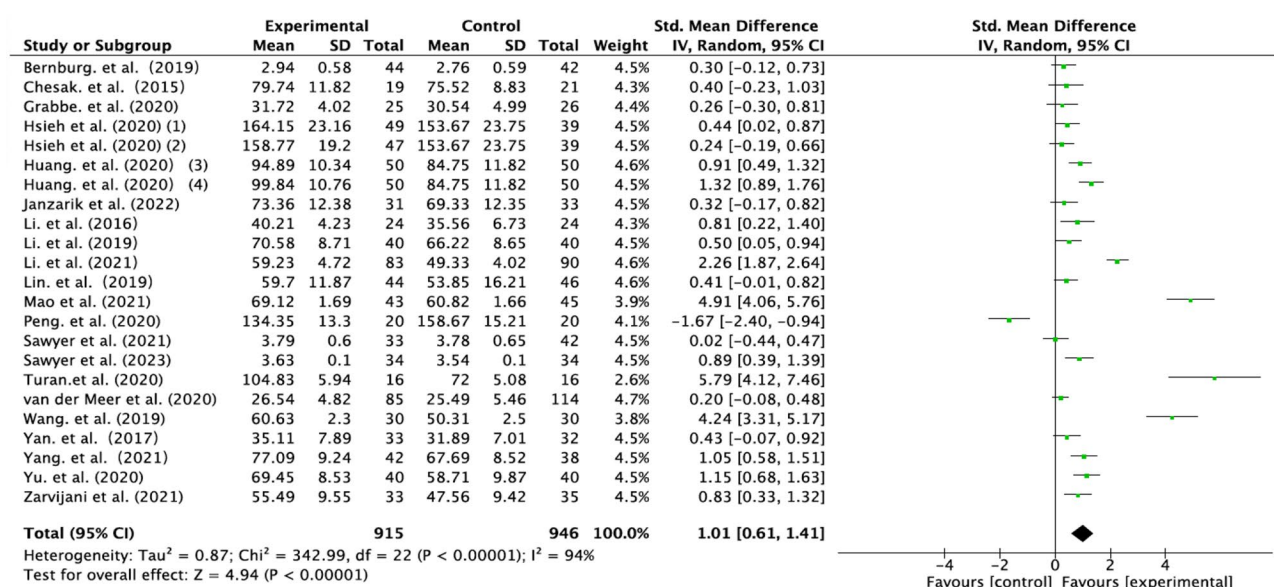
Fig. 4 Forest plot of resilience intervention programs' effectiveness. The forest plot shows standardized mean differences with 95% confidence intervals (CI) for 22 resilience-focused intervention comparisons in 21 studies. The black diamond at the bottom of the graph represents the pooled standardized mean difference following random effects meta-analyses. A positive value reflects that the corresponding resilience-focused intervention leads to an improvement in nurses' resilience with respect to the control group. (1) Biofeedback Training interventions vs. Treat as usual; (2) Smartphone-delivered Biofeedback Training interventions vs. Treat as usual; (3) Positive Psychology-Based Interventive Program vs. Treat as usual; (4) Professional Training combined with Positive Psychology Intervention vs. Treat as usual

Whereas, both group and individual interventions performed well in improving nurses' resilience. However, these results should be interpreted with caution due to the large heterogeneity between studies. Please see Table 3 for detailed results.

In terms of the heterogeneity test, the results showed a high level of heterogeneity among the 21 trials ($I^2 = 94\%$). Heterogeneity among SMACKT [52], SMART [53], CRM [38], BT [39], SDBT [39], PPBIP [35], The new Growth [50], GPT [47], SFBT [42], MBSR-M [40], GMT [48], and ACT [44] was virtually nonexistent ($I^2 = 0\%$), while

heterogeneity among the other interventions varied in strength from the above twelve (7-49%). Sensitivity analyses showed no significant change in the positive impact of resilience-focused interventions on nurses' resilience after the exclusion of studies with high risk of bias, as described in Table 4. In terms of the publication bias assessment, the funnel plot shows that the 21 included studies exist symmetrically within the triangle, indicating the absence of publication bias in the included studies in this study.

Table 3 Results of subgroup pairwise meta-analysis in the form and content of the intervention

Subgroups	Number of studies	Interventions	Total effect size [95%CI]	I^2
Form				
Online remote interventions	2	SDBT, SUPPORT coach	0.21 [-0.02, 0.45]	0%
Offline field interventions	20	AMP, EI, MBSR, PPBIP&PT, PPBIP, BBIP, PGP, ACT, GPT, BT, SFBT, GMT, MBSR-M, SMART, The new Growth, SMACKT, CRM, RISE, RSCI	1.12 [0.64, 1.59]	94%
Organization				
Group interventions	4	GPT, GMT, PGP, The new Growth	0.60 [0.32, 0.87]	14%
Individual interventions	18	AMP, EI, MBSR, PPBIP&PT, PPBIP, BBIP, ACT, BT, SFBT, MBSR-M, SMART, SMACKT, CRM, RISE, RSCI, SDBT, SUPPORT coach	1.11 [0.63, 1.59]	95%

Note. Total Effect size greater than 0 and a 95% *CI* not passing 0 is required to indicate that this type of intervention is significantly stronger than the control group in improving nurses' resilience. SMACKT=Stress Management and Coping Skill Training program, SMART=Stress Management and Resiliency Training program, CRM=Community Resiliency Model, BT=Biofeedback Training interventions, SDBT=Smartphone-delivered Biofeedback Training interventions, PPBIP=Positive Psychology-Based Interventive Program, PPBIP&PT=Professional Training combined with Positive Psychology Intervention, The new Growth=The new Growth Group Therapy, GPT=Group Painting Therapy, SFBT=Solution-Focused Brief Therapy, MBSR-M=Modified Mindfulness-Based Stress Reduction Program, EI=Emotional Intelligence training, RSCI=Resilience Support and Cognitive Intervention, RISE=Resilience, Insight, Self-Compassion, and Empowerment, PGP=Psychoeducational Group Program, AMP=Anger Management Psychoeducation, SUPPORT Coach=SUPPORT Coach APP-based intervention, MBSR=Mindfulness-Based Stress Reduction Program, GMT=Group Mindfulness Therapy, BBIP=Balint-based interventive program, ACT=Acceptance and Commitment Therapy

Table 4 Sensitivity analysis

Studies	Experimental group Mean (SD)	Control group Mean (SD)	Std. mean difference IV, Random, 95%CI	I^2 Overall I^2	rI^2	Total effect size [95%CI]
Bernburg et al. (2019) [52]	2.94 (0.58)	2.76 (0.59)	0.30 [-0.12, 0.73]	0%	-	0.48 [0.35, 0.62]
Chesak et al. (2015) [53]	79.74 (11.82)	75.52 (8.83)	0.40 [-0.23, 1.03]	0%		
Grabbe et al. (2020) [38]	31.72 (4.02)	30.54 (4.99)	0.26 [-0.31, 0.82]	0%		
Hsieh et al. (2020) [39] [a]	164.15 (23.16)	153.67 (23.75)	0.44 [0.02, 0.87]	0%		
Hsieh et al. (2020) [39][b]	158.77 (19.2)	153.67 (23.75)	0.24 [-0.19, 0.66]	0%		
Huang et al. (2020) [35] [c]	94.89 (10.34)	84.75 (11.82)	0.91 [0.49, 1.32]	0%		
Janzarik et al. (2022) [50]	73.36 (12.38)	69.33 (12.35)	0.32 [-0.17, 0.82]	0%		
Li et al. (2016) [47]	40.21 (4.23)	35.56 (6.73)	0.81 [0.22, 1.40]	0%		
Li et al. (2019) [42]	70.58 (8.71)	66.22 (8.65)	0.50 [0.05, 0.94]	0%		
Lin et al. (2019) [40]	59.7 (11.87)	53.85 (16.21)	0.41 [-0.01, 0.82]	0%		
Yan et al. (2017) [48]	35.11 (7.89)	31.89 (7.01)	0.43 [-0.07, 0.92]	0%		
Zarvijani et al. (2021) [44]	55.49 (9.55)	47.56 (9.42)	0.83 [0.33, 1.32]	0%		
Sawyer et al. (2023) [49]	3.63 (0.10)	3.54 (0.10)	0.89 [0.41, 1.37]	7%	7%	0.52 [0.38, 0.65]
van der Meer et al. (2020) [51]	26.54 (4.82)	25.49 (5.46)	0.20 [-0.09, 0.49]	22%	10%	0.47 [0.34, 0.61]
Sawyer et al. (2021) [54]	3.79 (0.60)	3.78 (0.65)	0.02 [-0.46, 0.49]	29%	13%	0.45 [0.31, 0.59]
Yang et al. (2021) [43]	77.09 (9.24)	67.69 (8.52)	1.05 [0.58, 1.51]	42%	22%	0.49 [0.34, 0.64]
Yu et al. (2020) [37]	69.45 (8.53)	58.71 (9.87)	1.15 [0.68, 1.63]	52%	31%	0.53 [0.37, 0.69]
Peng et al. (2020) [55]	134.35(13.3)	158.67 (15.21)	-1.67 [-2.40, -0.94]	75%	25%	0.44 [0.22, 0.66]
Turan et al. (2020) [45]	104.83(5.94)	72.00(5.08)	5.79 [4.12, 7.46]	83%	24%	0.54 [0.27, 0.81]
Wang et al. (2019) [41]	60.63(2.30)	50.31(2.50)	4.24 [3.31, 5.17]	89%	30%	0.71 [0.38, 1.03]
Li et al. (2021) [36]	59.23(4.72)	49.33(4.02)	2.26 [1.87, 2.64]	92%	32%	0.81 [0.44, 1.17]
Mao et al. (2021) [46]	69.12(1.69)	60.82(1.66)	4.91 [4.06, 5.76]	94%	35%	1.00 [0.58, 1.42]
Huang et al. (2020) [35] [d]	99.84 (10.76)	84.75 (11.82)	1.32 [0.89, 1.76]	94%	49%	1.01 [0.61, 1.41]

Note. Overall I^2 represents the overall magnitude of inter-study heterogeneity. Heterogeneity among the first 12 resilience-focused interventions was minimal (I^2=0%), whereas I^2 gradually increased during the gradual addition of the other 10 interventions, suggesting that inter-study heterogeneity gradually increased. In this context, rI^2 captures the change in heterogeneity when adding RCT *i* to the initial group of 12 trials with no heterogeneity. The formula can be interpreted as follows: $rI^2 = I^2_i - I^2_j$, I^2_i refers to the heterogeneity calculated after including RCT *i* to the analysis, where the analysis is initially based on the first 12 RCTs with zero heterogeneity. I^2_j represents to the value derived from the analysis of the first 12 RCTs, which is characterized by no heterogeneity. Total Effect size (95% CI) represents the overall intervention efficacy after adding to the study, if the value is greater than 0 (less than 0) and the 95% CI does not pass 0 then it means that the resilience-focused intervention has a positive (negative) effect in improving nurses' resilience. [a] Biofeedback Training intervention (BT) vs. Treat as usual; [b] Smartphone-delivered Biofeedback Training interventions (SDBT) vs. Treat as usual; [c] Positive Psychology-Based Interventive Program (PPBIP) vs. Treat as usual; [d] Professional Training combined with Positive Psychology Intervention (PPBIP&PT) vs. Treat as usual

Meta-regression

Meta-regressions were undertaken to account for the significant heterogeneity in the included studies. Moderators comprised of the participant's mean age, length of service, percentage of female nurses, and total duration of the intervention. These moderators were not significant predictors of resilience.

Network meta-analysis

Efficacy

21 trials with 22 interventions were included in our NMA. The network plot was shown in Fig. 5. The NMA suggested that Anger Management Psychoeducation (Effect size = 5.79, 95%CI 3.65,7.93), Emotional Intelligence training (Effect size = 4.91, 95%CI 3.32,6.51), and
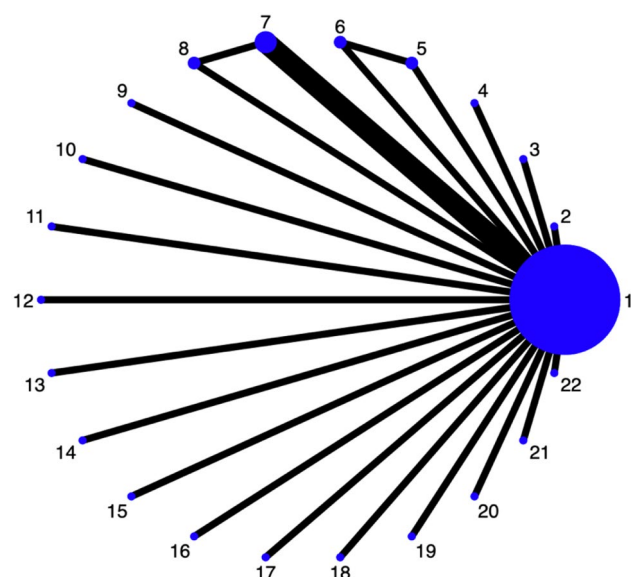
Fig. 5 Network plot for included treatment comparisons in effectiveness/acceptability. The blue dots represent the type of intervention, the size of the dots represents the number of people involved in the intervention, and the larger the number of people who receive the intervention, the larger the dot area. The black line represents a direct comparison between interventions, the thickness of which is equal to the number of direct comparison studies performed, and the greater the number of studies that make direct comparisons between the two interventions, the thicker the black line. 1 = Treat as Usual, 2 = Stress Management and Coping Skill Training program, 3 = Stress Management and Resiliency Training program, 4 = Community Resiliency Model, 5 = Biofeedback Training interventions, 6 = Smartphone-delivered Biofeedback Training interventions, 7 = Positive Psychology-Based Interventive Program, 8 = Professional Training combined with Positive Psychology Intervention, 9 = The new Growth Group Therapy, 10 = Group Painting Therapy, 11 = Solution-Focused Brief Therapy, 12 = Modified Mindfulness-Based Stress Reduction Program, 13 = Emotional Intelligence training, 14 = Resilience Support and Cognitive Intervention, 15 = Resilience, Insight, Self-Compassion, and Empowerment, 16 = Psychoeducational Group Program, 17 = Anger Management Psychoeducation, 18 = SUPPORT Coach APP-based intervention, 19 = Mindfulness-Based Stress Reduction Program, 20 = Group Mindfulness Therapy, 21 = Balint-based interventive program, 22 = Acceptance and Commitment Therapy

Mindfulness-Based Stress Reduction Program (Effect size = 4.24, 95%CI 2.60,5.88) were effective to increase the resilience performance of nurses compared with usual treatments (see Supplementary Fig. 1). Anger Management Psychoeducation (Effect size = 7.46, 95%CI 4.83,10.09), Emotional Intelligence training (Effect size = 6.58, 95%CI 4.37,8.79), Mindfulness-Based Stress Reduction Program (Effect size = 5.91, 95%CI 3.66,8.16), Professional Training combined with Positive Psychology Intervention (Effect size = 3.30, 95%CI 1.30,5.31), Positive Psychology-Based Interventive Program (Effect size = 3.12, 95%CI 1.38,4.85), Balint-based interventive program (Effect size = 2.71, 95%CI 0.62,4.81), Psychoeducational Group Program (Effect size = 2.56, 95%CI 0.46,4.66)), Acceptance and Commitment Therapy (Effect size = 2.50, 95%CI 0.39,4.60), Group Painting Therapy (Effect size = 2.48, 95%CI 0.35,4.61), Biofeedback Training interventions (Effect size = 2.14, 95%CI 0.05,4.23), and Solution-Focused Brief Therapy (Effect size = 2.17, 95%CI 0.07,4.26) significantly outperformed the Resilience Support and Cognitive Intervention in terms of improving nurses' resilience effectiveness (see Supplementary Fig. 1). Among various types of resilience-focused interventions, Anger Management Psychoeducation (SUCRA = 98.2), Emotional Intelligence training (SUCRA = 95), and Mindfulness-Based Stress Reduction Program (SUCRA = 92.4) were the most promising in improving resilience in nurses, and there was no significant difference in efficacy among these three resilience-focused interventions (see Supplementary Fig. 1 and 2). The SUCRA rankings were shown in Table 5.

Acceptability

The NMA suggested that Treat as Usual (SUCRA = 62.5), Psychoeducational Group Program (SUCRA = 60.1), Biofeedback Training interventions (SUCRA = 59.9), Community Resiliency Model (SUCRA = 58.4), Smartphone-delivered Biofeedback Training interventions (SUCRA = 58.1), and Balint-based interventive program (SUCRA = 57.3) topped the acceptance rankings, while Emotional Intelligence training (SUCRA = 41.3), SUPPORT Coach APP-based intervention (SUCRA = 34.3), Positive Psychology-Based Interventive Program (SUCRA = 30.2), Acceptance and Commitment Therapy (SUCRA = 27.1) and the new Growth Group Therapy (SUCRA = 19.4) performed relatively poorly in terms of acceptance. However, the 21 resilience-focused intervention included in this study were not statistically significantly different from Treat as Usual in terms of acceptability.

Ranking orders of all treatment measures

Based on the performance of the 22 interventions in terms of intervention effectiveness and acceptability, we

Table 5 Intervention relative ranking of efficacy and acceptability

Interventions	Efficacy			Acceptability		
	SUCRA	PrBest	MeanRank	SUCRA	PrBest	MeanRank
TAU	24.2	0	16.9	62.5	0	8.9
SMACKT	37.6	0	14.1	57	8.8	10
SMART	41.1	0	13.4	54.9	0.3	10.5
CRM	36	0	14.4	58.4	0.1	9.7
BT	43.4	0	12.9	59.9	9.6	9.4
SDBT	34.6	0	14.7	58.1	9.1	9.8
PPBIP	73.2	0	6.6	30.2	0.1	15.7
PPBIP&PT	74.2	0	6.4	44.8	4.1	12.6
The new Growth	38.3	0	14	19.4	0	17.9
GPT	53.1	0	10.8	56	9.3	10.2
SFBT	43.2	0	12.9	55.8	9.1	10.3
MBSR-M	41.5	0	13.3	54.2	0.3	10.6
EI	95.1	23.4	2	41.3	0.1	13.3
RSCI	2	0	21.6	55.4	9.6	10.4
RISE	28.8	0	16	44.1	0.1	12.7
PGP	55.4	0	10.4	60.1	0.7	9.4
AMP	98.1	69.7	1.4	56.1	9.4	10.2
SUPPORT Coach	33.9	0	14.9	34.3	0	14.8
MBSR	92.3	6.8	2.6	56	8.4	10.2
GMT	41.6	0	13.3	57	10.3	10
BBIP	59.4	0	9.5	57.3	10	10
ACT	53.2	0	10.8	27.1	0.6	16.3

Note. The surface under the cumulative ranking curve (SUCRA) metric was used to rank the effectiveness/ acceptability of each treatment and identify the best treatment. In this study, a larger SUCRA for a resilience-focused intervention represents a better effectiveness/ acceptability of the intervention. According to the size of SUCRA, interventions were ranked in order of effectiveness: AMP > EI > MBSR > PPBIP&PT > PPBIP > BBIP > PGP > ACT > GPT > BT > SFBT > GMT > MBSR-M > SMART > The new Growth > SMACKT > CRM > SDBT > SUPPORT Coach > RISE > TAU > RSCI; Interventions ranked in order of acceptance: TAU > PGP > BT > CRM > SDBT > BBIP > GMT > SMACKT > AMP > MBSR > GPT > SFBT > RSCI > SMART > MBSR-M > PPBIP&PT > RISE > EI > SUPPORT Coach > PPBIP > ACT > The new Growth. TAU = Treat as Usual, SMACKT = Stress Management and Coping Skill Training program, SMART = Stress Management and Resiliency Training program, CRM = Community Resiliency Model, BT = Biofeedback Training interventions, SDBT = Smartphone-delivered Biofeedback Training interventions, PPBIP = Positive Psychology-Based Interventive Program, PPBIP&PT = Professional Training combined with Positive Psychology Intervention, The new Growth = The new Growth Group Therapy, GPT = Group Painting Therapy, SFBT = Solution-Focused Brief Therapy, MBSR-M = Modified Mindfulness-Based Stress Reduction Program, EI = Emotional Intelligence training, RSCI = Resilience Support and Cognitive Intervention, RISE = Resilience, Insight, Self-Compassion, and Empowerment, PGP = Psychoeducational Group Program, AMP = Anger Management Psychoeducation, SUPPORT Coach = SUPPORT Coach APP-based intervention, MBSR = Mindfulness-Based Stress Reduction Program, GMT = Group Mindfulness Therapy, BBIP = Balint-based interventive program, ACT = Acceptance and Commitment Therapy

constructed a planar coordinate system with efficacy and acceptability as axes to visualize the combined intervention potential of the interventions (see Fig. 6). According to the efficacy and acceptability, the optimal number of clusters of interventions is 4 (Cophenetic Correlation Coefficient = 0.91, the value of Cophenetic Correlation Coefficient ranges from 0 to 1, the closer to 1 means the more reliable the results of cluster analysis), which means that the 22 interventions can be classified into 4 categories, which are High Efficacy – High Acceptability (Anger Management Psychoeducation, Mindfulness-Based Stress Reduction Program, Emotional Intelligence training, Professional Training combined with Positive Psychology Intervention), Medium Efficacy – High Acceptability (Treat as Usual, Psychoeducational Group Program, Biofeedback Training interventions, Smartphone-delivered Biofeedback Training interventions, Balint-based interventive program, Stress Management and Coping Skill Training program, Group Mindfulness Therapy, Group Painting Therapy, Solution-Focused Brief Therapy, Stress Management and Resiliency Training program, Modified Mindfulness-Based Stress Reduction Program, Resilience, Insight, Self-Compassion, and Empowerment, SUPPORT Coach APP-based intervention), Medium Efficacy – Low Acceptability (Positive Psychology-Based Interventive Program, Acceptance and Commitment Therapy, The new growth Group Therapy), and Low Efficacy – High acceptability (Resilience Support and Cognitive Intervention).

Discussion

To the best of our knowledge, the present study is the first to utilize NMA to indirectly compare the efficacy and acceptability of resilience-focused interventions in nurses. In this NMA, we performed detailed comparisons of multiple resilience-focused interventions on their efficacy and acceptability. The pooled effect size did not significantly change before and after removing studies
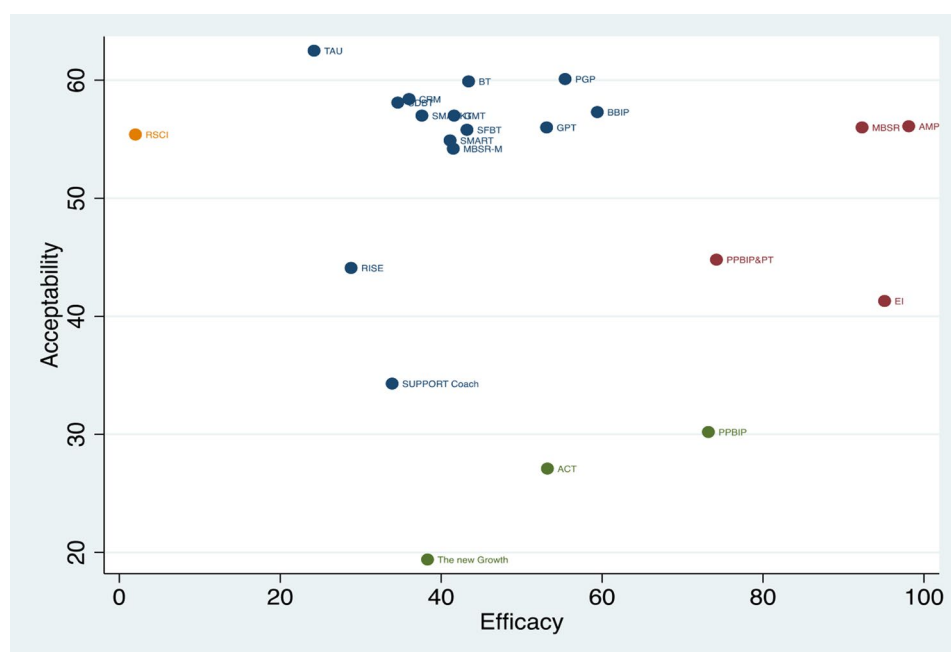
Fig. 6 A comprehensive evaluation of intervention potential according to SUCRA on the efficacy and acceptability of resilience-focused interventions. The X-axis represents the SUCRA values for efficacy, while Y-axis represents the SUCRA values for acceptability. Larger SUCRA values are indicative of a greater probability of higher ranking. Intervention is represented by dots in this coordinate system. The color of the dots represents different clusters. reddish brown dots represent clusters with good performance in terms of both efficacy and acceptability, including AMP, MBSR, EI, PPBIP&PT (high efficacy - high acceptability type). The clusters represented by the blue dots have good or moderate acceptability and relatively poor efficacy performance, including TAU, PGP, BT, CRM, SDBT, BBIP, SMACKT, GMT, GPT, SFBT, SMART, MBSR-M, RISE, SUPPORT Coach (medium efficacy - high efficacy type). The clusters represented by the green dots have a moderate performance in terms of efficacy and a relatively poor performance in terms of acceptability, including PPBIP, ACT, The new growth (medium efficacy - low acceptability type). Orange dots represent clusters that perform well in acceptability and extremely poorly in acceptance-focused interventions, including RSCI (low-efficacy-high acceptability type). TAU = Treat as Usual, SMACKT = Stress Management and Coping Skill Training program, SMART = Stress Management and Resiliency Training program, CRM = Community Resiliency Model, BT = Biofeedback Training interventions, SDBT = Smartphone-delivered Biofeedback Training interventions, PPBIP = Positive Psychology-Based Interventive Program, PPBIP&PT = Professional Training combined with Positive Psychology Intervention, The new Growth = The new Growth Group Therapy, GPT = Group Painting Therapy, SFBT = Solution-Focused Brief Therapy, MBSR-M = Modified Mindfulness-Based Stress Reduction Program, EI = Emotional Intelligence training, RSCI = Resilience Support and Cognitive Intervention, RISE = Resilience, Insight, Self-Compassion, and Empowerment, PGP = Psychoeducational Group Program, AMP = Anger Management Psychoeducation, SUPPORT Coach = SUPPORT Coach APP-based intervention, MBSR = Mindfulness-Based Stress Reduction Program, GMT = Group Mindfulness Therapy, BBIP = Balint-based interventive program, ACT = Acceptance and Commitment Therapy

with high heterogeneity, despite the analysis showing a high degree of variability among studies. This implies that the findings might not have been adversely affected by heterogeneity. The meta-regression analysis's findings also refuted the interpretation of heterogeneity based on factors like the sample's mean age, length of service, percentage of female nurses, and the intervention's overall duration. This suggests that there may be additional factors influencing the heterogeneity seen in the included research. Disparities in methods may be one of these issues. For instance, no significant heterogeneity was detected among studies within the subgroup of group interventions or those in the online remote interventions category, whereas substantial heterogeneity persisted across studies in both the individual interventions subgroup and the offline field interventions subgroup. Furthermore, disparities in participants' experience or comprehension of the intervention may contribute to heterogeneity in its effects. Additionally, the context in

which the intervention is implemented, the characteristics of the intervention providers, and the selection of assessment instruments may serve as potential moderators of the intervention's effectiveness. While it is logical to consider these factors as sources of heterogeneity, their examination was hindered by the absence of systematic reporting across the included trials.

Pairwise meta-analysis showed that resilience-focused interventions had a protective effect on nurses' resilience, while subgroup analysis found that offline field interventions performed better compared to online remote interventions. And both group interventions and individual interventions are effective in improving nurses' resilience. Further, the NMA found that only Anger Management Psychoeducation, Emotional Intelligence training and Mindfulness-Based Stress Reduction Program were effective to increase the resilience performance of nurses compared with usual treatments. Although no differences in acceptability were found among all the included

resilience-focused interventions, when combining both efficacy and acceptability performance, we found that Anger Management Psychoeducation, Mindfulness-Based Stress Reduction Program, Emotional Intelligence training, and Professional Training combined with Positive Psychology Intervention had the best potential of the 21 interventions. Since Professional Training combined with Positive Psychology Intervention was not found to be significantly different from control group efficacy in pairwise meta-analysis. Therefore, we focus only on the between-group comparisons and the other three resilience-focused interventions that fall into the High Efficacy – High-Acceptability category, discussing their combined intervention potential in turn and providing recommendations for application.

Offline field interventions are stronger than online remote interventions in improving nurses' resilience in a combination of interventions

A pairwise meta-analysis found that face-to-face resilience-focused interventions significantly outperformed control groups in enhancing nurses' resilience, while online interventions showed no significant difference compared to the control groups. Furthermore, the results of the Network Meta-Analysis (NMA) indicated that Smartphone-delivered Biofeedback Training interventions and SUPPORT Coach APP-based interventions using online remote approaches were less effective, ranking 18th and 19th out of 22, respectively. This finding aligns with the results of Bruggeman-Everts et al. [56]. Their study showed that face-to-face mental health education did not yield significantly better results in improving mental health compared to two web-based interventions: physiotherapist-guided ambulant activity feedback and psychologist-guided web-based mindfulness-based cognitive therapy. In other words, online interventions did not demonstrate greater advantages in promoting mental health compared to face-to-face formats. Additionally, the NMA results suggested that face-to-face interventions, such as Anger Management Psychoeducation, Mindfulness-Based Stress Reduction Programs, and Emotional Intelligence Training, were more effective than online counterparts in improving nurses' resilience, which is consistent with the findings of some researchers. For instance, Spijkerman et al. [57] integrated the performance of internet-based Mindfulness-Based Interventions (MBIs) across various populations and compared the results with those of earlier face-to-face interventions. They found that the impact of web-based MBIs on population mental health was generally smaller than that of face-to-face MBIs.

However, given the heterogeneity between studies, it is premature to draw any definitive conclusions based on the evidence presented above. For example, nurses with psychological symptoms may benefit more from internet-based psychological interventions compared to their colleagues without such symptoms [58]. Furthermore, among the included studies, only Marlene et al. focused on newly licensed registered nurses reporting high levels of burnout and stress, while other studies were conducted with populations that did not report psychological symptoms. As a result, the effectiveness of online interventions may have been underestimated. The nurse population, in general, may possess stronger psychological coping skills, leaving less room for improvement in resilience, which could partly explain the lower efficacy of online interventions for resilience due to a potential floor effect [57]. Another possible explanation is the poor adherence to online psychological interventions, which may limit their potential impact on nurses' resilience [59–61]. Statistically, two web-based psychological intervention studies showed a dropout rate of 30.66%, higher than the dropout rate of face-to-face interventions (14.77%). Therefore, we cannot rule out the possibility that low adherence hindered the optimal effectiveness of web-based psychological interventions.

Although the limitations of online psychological interventions are unavoidable and cannot be ignored in some cases, evidence suggests that electronic health technologies employing engagement strategies [62], such as program features designed to encourage adherence or facilitator-led strategies, can help encourage participant commitment and reduce the negative impact of low adherence on the effectiveness of online interventions. In such cases, the comparative results obtained may provide more meaningful guidance for clinical practice. This raises new demands for clinical managers to implement online resilience-focused interventions that incorporate engagement strategies, in order to further compare the effectiveness of different forms of resilience-focused interventions for nurses.

Anger management psychoeducation on nurses' resilience

Both pairwise meta-analysis and NMA showed that Anger Management Psychoeducation had a significant positive effect in improving nurses' resilience. Rank probability analysis indicated that Anger Management Psychoeducation had the highest probability to be rank 1, meaning that it was the most effective resilience-focused intervention for improving nurses' resilience. Our finding is similar to that of Bauer et al. [63]. The rationale for this program can be explained by the knowledge, attitudes, and practices (KAP) theory [64]. Initially, the researcher improved the nurses' cognitive level by educating them about the perception of angry, the mechanisms of events, thoughts and behaviors, and coping strategies based on books and literature related to "Grupla Psikolojik Danışma Uygulamaları" (Group Counseling Practice).

This further improved the nurses' awareness of anger and dialectical consciousness, which helped the nurses rationally choose reasonable emotional coping strategies and behaviors to alleviate the level of stress and improve their resilience. Additionally, two more findings from the study are noteworthy. First, the study noted that the level of resilience of the nurses in the intervention group remained on a significant upward trend over time, a phenomenon that the researchers believe may be related to the fact that the participants generally possessed a high level of educational attainment (bachelor's degree), exercised regularly, and engaged in social interactions. Moreover, the researchers underscore the important positive impact of incorporating the group interaction model on outcomes [65]. The reason for this is that it may allow for the catharsis of anger and the dissemination of effective coping strategies. This revealed that nurses should value improving their own knowledge, regular participation in sports and social interaction to increase mastery of the intervention content and inner energy, while managers should have the flexibility to combine group and one-on-one intervention patterns that work together to improve nurses' resilience.

Mindfulness-based stress reduction program on nurses' resilience

Both pairwise meta-analysis and NMA showed that the Mindfulness-Based Stress Reduction Program (MBSR) had a significant positive effect in improving nurses' resilience. Rank probability analysis indicated that Mindfulness-Based Stress Reduction Program had the highest probability to be rank 2, namely it was the most effective way of improving nurses' resilience other than Anger Management Psychoeducation, in line with previous findings [66]. MBSR, an educationally based program that focuses on training in the contemplative practice of mindfulness techniques, has been consistently found to have a significant positive impact on alleviating nurses' emotional distress such as stress [66], burnout [67], anxiety, and depression [68], and on maintaining nurses' mental health. The exact mechanisms underlying the effects of MBSR on nurses' resilience are still unknown, but several hypotheses have been proposed to explain. It may have enhanced nurses' awareness and intervention adherence by increasing their knowledge of mindfulness techniques. Afterwards, it increases nurses' attention to their emotional disorders by guiding them in positive breathing, meditation, and body scanning to make them consciously aware of the discomfort they experience. Finally, the mechanism of allowing nurses to assess their inner feelings with a calm mind enhances their ability to maintain good emotional regulation in the face of adversity. Nursing administrators should educate nurses about the advantages and techniques of mindfulness in mental health maintenance, improve nurses' application of positive breathing, meditation, and somatic scanning, improving nurses' resilience.

Emotional intelligence training on nurses' resilience

Both pairwise meta-analysis and NMA showed that Emotional Intelligence training had a significant positive effect in improving nurses' resilience, in line with previous findings [69, 70]. Moreover, rank probability analysis indicated that Emotional Intelligence training had the highest probability to be rank 3, predicting it was the most effective way of improving nurses' resilience other than Anger Management Psychoeducation and Mindfulness-Based Stress Reduction Program. The mechanism of Emotional Intelligence training is similar to that of Anger Management Psychoeducation [71], which both emphasize an individual's ability to perceive, facilitate, understand, and regulate emotions [70]. Based on the capacity model developed by Salovey and Mayer and previous evidence, Emotional Intelligence training may be improving nurses' resilience through several mechanisms. First, emotional intelligence can help nurses accurately recognize and understand their own emotions and adopt appropriate strategies to manage and regulate them, so nurses with high emotional intelligence are more able to remain calm and show higher resilience in the face of adversities [69]. Also, the higher the emotional intelligence, the better the nurses are able to manage emotional outbursts caused by stress in the workplace and strengthen the nurses' professional competence [72]. This makes it easier for nurses to build rapport with patients and work effectively with other healthcare team members. This positive interpersonal interaction and collaboration helps to reduce workplace stress and increase nurses' resilience [73]. While the similarities between the core concepts of Emotional Intelligence training and Anger management Psychoeducation may not be coincidental, it is likely that nurses' ability to perceive, facilitate, understand, and regulate emotions will play an important role in improving their own resilience. In maintaining nurses' mental health, generalization of relevant knowledge and skills should be an integral part of intervention.

Beyond the three interventions we were interested in that performed well in improving nurses' resilience, we also noted anomalous performance with Resilience Support and Cognitive Intervention. Both pairwise meta-analysis and the NMA showed that not only did nurses' resilience not improve after the implementation of this intervention, but it also exacerbated the nurses' distress. This may be related to the social and public health context in which the intervention was implemented. January to March 2020 was the initial phase of the COVID-19 outbreak in China [74]. Frontline caregivers are generally in a state of extreme panic due to limited health

knowledge about the virus and the lack of a systematic prevention and control policy [75]. And there may be several possible explanations for the failure of the intervention constructed by Peng et al. First, nurses have difficulty in focusing their attention on receiving knowledge about psychological management when they are in extremely severe mental distress (e.g., acute panic, post-traumatic stress disorder), and therefore have poor knowledge acquisition and application. Second, in the face of an acute public health event, interventions aimed solely at mental health cannot help nurses to solve the survival problem (the most important stressor), so that the effectiveness of interventions is low. Therefore, they cannot withstand the acute physical and psychological stress caused by a serious public health event. In contrast, the use of prevention and control strategies that focus on survival issues, the improvement of shift systems, and socially credible promises of well-being, such as financial compensation, are likely to be more effective [76]. This suggests that nursing administrators should be less invested in psychotherapy alone when maintaining nurses' mental health during acute public health events, and should instead construct interventions in conjunction with highly effective targets after socio-contextual assessments.

Internationalization and cross-cultural applicability

Given that the 22 studies included in this research were conducted across diverse countries and regions (e.g., China, the U.S., Germany, Taiwan, the Netherlands, Tehran, Turkey) and various healthcare settings (e.g., tertiary hospitals, psychiatric centers), the findings are generally applicable. That said, differences in healthcare systems and institutional factors may influence the intervention outcomes. For example, given that the U.S. healthcare system is primarily privatized while China relies on public hospitals, the work environment, social support, and stress perceptions of nurses may differ, which could lead to variations in resilience between nurses. Additionally, differences in social support systems may influence the effectiveness of interventions. Nordic countries have well-established social welfare, whereas in other nations, particularly developing countries, social support may be weaker, potentially leading to lower acceptance of interventions among nurses in these regions. Moreover, interventions may have varying effects across different cultural contexts. For instance, because Western cultures emphasize individual emotional expression, emotional intelligence training may align more closely with their cultural values, whereas in some East Asian countries, emotional restraint and control are more common, and collective and familial support may outweigh individual emotional management. As a result, the effectiveness of such interventions may be diminished. Economic disparities may

also hinder the implementation of online interventions. Overall, our findings may require further adjustments and validation in additional cultural contexts. Nursing administrators should consider the specific conditions of their region and select the most appropriate interventions based on the characteristics of the local healthcare system.

Strength and limitations

To our knowledge, this is the first study that comprehensively integrated the available evidence of 21 different resilience-focused interventions used for improving nurses' resilience. Since our NMA included only randomized controlled trials and applied the clustering principle to combine the effectiveness and acceptability of the intervention, so that the results are highly accurate and credible, even though they may be slightly different from future studies. Nevertheless, this network meta-analysis has several limitations that should be acknowledged.

Firstly, the absence of a number of head-to-head controlled studies limits the ability to conduct cross-intervention indirect comparisons. Second, we included only RCTs that utilized at least one measure of resilience, excluding studies that may have an impact on resilience but did not employ relevant assessment tools. This, in turn, restricts the scope of interventions covered in this study. Then, high SUCRA values provide only supportive, not conclusive evidence. While the size of SUCRA can help researchers rank intervention effects, it does not show whether differences between treatments are clinically significant, and the absolute difference between the best treatment and other treatments may be negligible. Although we have carefully searched the potential resilience-focused interventions for nurses, language was restricted to English and Chinese, which may miss some relevant studies published in other languages. Therefore, the results should be interpreted with caution. Another important limitation was the limited availability of data on demographic and work-related characteristics that were missing in the included studies, and we were unable to conduct further subgroup analyses to explore whether these factors influenced the effectiveness of different interventions. This means that we cannot determine whether an intervention is particularly effective or deprazed in a particular population or setting. This limitation prevents us from providing more personalized recommendations based on individual characteristics or specific work circumstances.

In the future, we recommend that more researchers adopt the approach of Wahl et al. [77] seeking a "benchmark" that can be applied in the field of resilience. This would enhance the comparability of study results and simplify communication among researchers. Subsequently, we recommend that researchers expand the

scope of the study to cover a wider range of resilience-focused interventions, particularly those that incorporate pharmacological approaches, which may improve the applicability and accuracy of the study. In addition, future research should aim to collect more detailed data on demographic and work-related characteristics for further dissection. By doing so, researchers can better understand the effectiveness of different interventions for different subpopulations of nurses and work environments, ultimately contributing to the development of more personalized and context-sensitive resilience-focused interventions for nurses. In conclusion, we urge researchers to focus on the significance of qualitative insights to thoroughly evaluate the acceptability of interventions in order to offer additional reference data for improving the scientificity, flexibility, and adaptability of intervention programs.

Conclusion

The present network meta-analysis provides the first exhaustive comparison of efficacy and acceptability of 21 resilience-focused interventions for improving nurses' resilience, and arrives at a conclusion that resilience-focused interventions have a protective effect on nurses' resilience. Among them, offline field interventions performed better overall in improving nurses' resilience compared to online remote interventions. Both group and individual interventions were effective in improving nurses' resilience. More specifically, Anger Management Psychoeducation, Mindfulness-Based Stress Reduction Program, and Emotional Intelligence training, which were categorized as high-efficacy-high-acceptability, had the best potential to improve nurses' resilience among the 21 interventions. In the future, well-designed randomized clinical trials with clear intervention protocols are needed to verify the therapeutic effectiveness of emotion perception, facilitation, understanding, and regulation techniques, as well as mindfulness techniques.

Relevance to clinical practice

Improving patient safety requires effective treatment of nurses' mental health. Although resilience-focused interventions have potential, there are obstacles to their implementation, including: (i) time constraints brought on by shift variability and high patient-to-nurse ratios; (ii) a lack of resources (such as private spaces or trained facilitators); (iii) the stigma associated with talking about mental health in clinical settings; and (iv) rigid interventions that clash with unpredictable workflows. Heterogeneous baseline resilience levels and compassion fatigue further complicate sustained participation. Prioritizing adaptive scheduling (e.g., 10-minute resilience modules during handoffs), gaining leadership support, and utilizing already-existing wellness infrastructures are some

ways that institutions might address these issues. Simultaneously, diverse support teams and technologically advanced solutions (such as mobile apps for on-demand training) can improve viability. To address the distinct socio-professional pressures faced by nurses, administrators must strike a balance between contextual adjustments and evidence-based solution selection.

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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