



## OPEN Systematic review of healthcare-led and lay-led interventions for type 2 diabetes in community settings

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Models led by trained non-professionals or incorporating peer support may serve as promising alternative approaches to address shortages of healthcare personnel and substantial economic burdens. However, no comprehensive meta-analysis has yet evaluated whether models led by non-healthcare professionals and supported by peers can achieve effectiveness comparable to those led by healthcare professionals and without peer support in improving metabolic outcomes. This meta-analysis aims to address this existing knowledge gap. Randomized controlled trials (RCTs) were systematically searched in eight Chinese and English databases from their inception to February 1, 2025. Meta-analyses, subgroup analyses, and sensitivity analyses were performed using RevMan 5.4 and Stata 18.0 software. The quality of evidence for each outcome indicator was evaluated using the online tool GRADEpro GDT. A total of 30 studies were included in the meta-analysis. The findings demonstrated that community-based interventions had a significant effect on improving HbA<sub>1c</sub> ( $MD = -0.57$ , 95%  $CI = -0.69$  to  $-0.45$ ,  $P < 0.00001$ ), 2-h plasma glucose ( $MD = -1.68$ , 95%  $CI = -2.24$  to  $-1.12$ ,  $P < 0.00001$ ), fasting glucose ( $MD = -0.98$ , 95%  $CI = -1.16$  to  $-0.79$ ,  $P < 0.00001$ ), total cholesterol ( $MD = -0.33$ , 95%  $CI = -0.54$  to  $-0.11$ ,  $P = 0.003$ ), triglycerides ( $MD = -0.60$ , 95%  $CI = -0.87$  to  $-0.34$ ,  $P < 0.00001$ ), and body mass index ( $MD = -1.40$ , 95%  $CI = -1.99$  to  $-0.80$ ,  $P < 0.00001$ ) in patients with type 2 diabetes. However, the interventions did not lead to significant changes in high-density lipoprotein ( $MD = 0.06$ , 95%  $CI = -0.01$  to  $0.13$ ,  $P = 0.09$ ) or low-density lipoprotein ( $MD = -0.33$ , 95%  $CI = -0.94$  to  $0.28$ ,  $P = 0.29$ ). Subgroup analyses indicated that interventions led by healthcare professionals were more effective than those led by non-healthcare professionals in improving HbA<sub>1c</sub> (subgroup difference  $P < 0.05$ ). Moreover, peer support was less effective than non-peer support in reducing HbA<sub>1c</sub> levels (subgroup difference  $P = 0.0003$ ). A comprehensive assessment of the quality of evidence included in this study indicates that, despite the substantial sample size, the level of evidence for all outcome measures remains low. Despite the low certainty of evidence, the achievement of clinically meaningful reductions in HbA<sub>1c</sub> (approximately 0.30% and 0.26% in subgroup analyses) supports the use of non-professional and peer-support models as pragmatic, second-best alternatives to professional-led care in resource-limited settings.

**Keywords** Type 2 diabetes, Community health workers, Peer support, Community management, Meta-analysis

Type 2 diabetes (T2D) is a chronic metabolic disorder characterized by persistent disturbances in glucose, protein, and lipid metabolism, resulting from a complex interplay of genetic, environmental, and lifestyle factors<sup>1</sup>. It is associated with a high risk of microvascular and macrovascular complications, as well as elevated rates of mortality and disability<sup>2</sup>. According to the 11th edition of the International Diabetes Federation's Global Diabetes Atlas, China has the largest number of individuals with diabetes worldwide. In 2024, the estimated number of adults with diabetes in China reached approximately 148 million, with projections indicating an increase to 168.3 million by 2050<sup>3</sup>.

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Evidence indicates that community-based diabetes management can leverage the strengths of primary healthcare systems to promote healthy lifestyles, control key risk factors, facilitate appropriate patient triage, and manage medical costs effectively<sup>4,5</sup>. However, current models face significant challenges, including shortages of trained healthcare personnel and substantial economic burdens<sup>6</sup>, particularly in resource-limited settings. In this context, the development of cost-effective and less resource-intensive management strategies is critically important. To reduce reliance on professional healthcare providers, trained non-professionals—such as peer educators and community health workers (CHWs)—have been increasingly integrated into community diabetes care, demonstrating promising outcomes<sup>7,8</sup>. Furthermore, growing evidence suggests that such lay-led approaches are cost-effective in diabetes management, adding to their potential value<sup>9–11</sup>. However, the effectiveness of these models may be influenced by challenges such as ensuring the quality and standardization of training, adequate supervision, and the scope of responsibilities assigned to lay personnel. Non-healthcare professionals refer to individuals without formal clinical training who engage in health promotion activities under the supervision of qualified healthcare providers<sup>12</sup>. These personnel primarily include peer educators and CHWs. Peer educators<sup>13</sup> are individuals from the target population who share similar sociodemographic or experiential backgrounds with patients; they deliver education and support through shared experiences and skill-building. CHWs<sup>14</sup>, also known as lay health workers or community health representatives, are frontline public health practitioners who are trusted members of their communities and possess deep contextual knowledge of local health needs.

Several previous systematic reviews and meta-analyses have confirmed the role of interventions that are not supported by healthcare professionals and peers compared with usual care for type 2 diabetes. Meta-analyses of peer support models have shown that peer support interventions significantly improve HbA<sub>1c</sub> levels compared with usual care, highlighting their value as an adjunct to standard diabetes management<sup>15,16</sup>. Similarly, for interventions led by community health workers and other lay professionals, systematic reviews consistently reported statistically significant and clinically meaningful reductions in HbA<sub>1c</sub>, affirming the absolute efficacy of the model relative to the passive control condition<sup>17–19</sup>. However, the evidence regarding their impact on comprehensive metabolic outcomes, particularly lipid profiles, remains inconsistent and inconclusive<sup>20,21</sup>. These conflicting findings highlight a significant gap in understanding the full scope of metabolic benefits offered by these alternative models.

The existing comprehensive literature, however, has an important limitation. The prevailing, unresolved question has evolved: it is no longer merely “Is peer support effective?” but rather “How effective is it compared to the standard of professional-led care?” Similarly, for implementer selection, the key inquiry is whether non-healthcare professionals can achieve outcomes comparable to healthcare professionals. To the best of our knowledge, no previous meta-analysis has specifically undertaken this crucial comparison. This meta-analysis therefore aims to directly compare the effectiveness of community-based interventions led by non-healthcare professionals or incorporating peer support with that of those led by healthcare professionals or without peer support in improving metabolic outcomes for patients with type 2 diabetes.

## Methods

### Protocol and registration

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines<sup>22</sup> (Supporting Information 1). The study protocol was prospectively registered in PROSPERO (registration number: CRD420251084793).

### Search strategy and inclusion criteria

A comprehensive literature search was performed across eight databases: PubMed, Cochrane Library, Web of Science, Embase, China National Knowledge Infrastructure (CNKI), Wanfang Data Knowledge Service Platform, VIP Database for Chinese Technical Periodicals, and the Chinese Biomedical Literature Database, covering all publications up to February 2025. The search strategy combined Medical Subject Headings (MeSH) terms and free-text keywords, which were iteratively refined through pilot testing. Key search terms included “Diabetes Mellitus, Type 2,” “Community Health Services,” and “Randomized Controlled Trial.” Detailed search strategies for the four English-language databases are provided in Supporting Information 2.

Studies were eligible for inclusion if they met the following criteria: (1) randomized controlled trial (RCT) design; (2) participants aged  $\geq 18$  years with a confirmed diagnosis of T2D; (3) interventions delivered in community settings by healthcare providers, CHWs, or peer educators; (4) control group receiving standard community care or routine management; and (5) intervention duration of at least six months.

Exclusion criteria comprised studies involving patients with severe acute or chronic comorbidities, those lacking detailed intervention descriptions, and publications for which full texts were unavailable.

For the subgroup analyses comparing different implementing entities or intervention methods, we adopted an “either-or” inclusion criterion. Specifically, studies were excluded from these analyses if they utilized hybrid models (e.g., involving both healthcare and non-healthcare professionals, or incorporating both peer and non-peer support). This ensured that each subgroup contained only studies with a single, clearly defined type of implementer or intervention for a direct comparison.

Literature screening and data extraction were managed using EndNote and Rayyan software. Two reviewers (Xuanning Luo and Chuanlei Zheng) independently screened titles, abstracts, and full texts. Any discrepancies were first discussed between them to reach a consensus. If an agreement could not be reached, a third senior investigator (Qingfeng Wu) was consulted to make the final decision.

### Data extraction and outcome assessments

Data were independently extracted by two authors (Xuanning Luo and Chuanlei Zheng) using a standardized form. Extracted information included study characteristics such as baseline demographics, intervention

components (type, duration, frequency), and outcome measures. Descriptive statistics—including sample sizes, means, and standard deviations for both intervention and control groups—were recorded. Primary outcomes were glycated hemoglobin (HbA<sub>1c</sub>), fasting plasma glucose (FPG), and 2-h postprandial glucose (2h-PPG). Secondary outcomes encompassed total cholesterol (TC), high-density lipoprotein (HDL), low-density lipoprotein (LDL), triglycerides (TG), and body mass index (BMI). For cluster-randomized trials, we preferentially extracted effect estimates (e.g., mean differences) and measures of variance (e.g., confidence intervals or standard errors) that were already adjusted for the intra-cluster correlation (ICC), as reported by the primary study authors using methods such as generalized estimating equations (GEE) or mixed-effects models.

### Quality appraisal

Given that all included studies were RCTs, methodological quality was assessed using the Cochrane Collaboration's risk of bias tool. Two reviewers (Xuanning Luo and Chuanlei Zheng) independently evaluated seven domains: random sequence generation (selection bias), allocation concealment (selection bias), blinding of participants and personnel (performance bias), blinding of outcome assessors (detection bias), incomplete outcome data (attrition bias), selective reporting (reporting bias), and other potential biases. Each domain was classified as low, unclear, or high risk of bias. A Summary of Findings table was generated using GRADEpro GDT software (Evidence Prime Inc., McMaster University, 2020) to evaluate the overall certainty of evidence. Conflicts were resolved through consultation with additional team members.

### Operational definition of subgroup analysis

#### *Classification of implementing entities*

- (1) *Healthcare professional-Led*: Interventions primarily delivered by licensed healthcare providers—such as physicians, nurses, and other certified clinicians—who assume responsibility for clinical decision-making, patient education, and follow-up assessments.
- (2) *Non-healthcare professional-Led*<sup>12</sup>: Interventions led by CHWs, peer educators, or similar non-clinical personnel who serve as the primary point of contact and provide ongoing support to patients.
- (3) *Hybrid intervention*: Models in which leadership responsibilities are shared between healthcare and non-healthcare professionals, with neither group clearly dominant in intervention delivery.

#### *Classification of intervention methods*

- (1) *Peer support*<sup>23</sup>: Defined as emotional, appraisal, and informational support provided by individuals with lived experience of diabetes who share key characteristics with the target population. Such support aims to address psychosocial and behavioral challenges related to disease management.
- (2) *Non-peer support*: Interventions delivered by trained professionals without personal experience of the condition, excluding peer-led components.
- (3) *Hybrid intervention*: Models integrating both professional and peer support elements, with balanced contributions from both parties.

### Data analysis

Meta-analyses were performed using RevMan 5.4 and Stata 18.0. All outcomes were continuous variables; mean difference (MD) was used as the effect size measure, reported with 95% confidence intervals (CIs). Statistical significance was set at  $P < 0.05$ . Heterogeneity was assessed using the  $I^2$  statistic and Cochran's Q test. A random-effects model was applied in cases of substantial heterogeneity ( $I^2 \geq 50\%$  or  $P \leq 0.10$ ); otherwise, a fixed-effects model was used ( $I^2 < 50\%$  and  $P > 0.10$ ). For the meta-analysis of cluster-randomized trials, we utilized the adjusted effect estimates (accounting for intra-cluster correlation) as reported by the primary study authors. All included cluster-RCTs provided such adequately adjusted analyses. Should substantial heterogeneity be identified, we pre-planned to explore its sources using meta-regression analysis with key study-level covariates. Predefined subgroup analyses were conducted based on implementing entities (healthcare vs. non-healthcare professionals) and intervention methods (peer vs. non-peer support). Sensitivity analyses were performed by sequentially excluding individual studies to evaluate result robustness. Publication bias was assessed using Egger's regression asymmetry test.

## Results

### Search results

In the initial and updated literature search, a total of 9019 records were identified after duplicate removal. After screening titles and abstracts, 2385 full-text articles were reviewed for further evaluation. Ultimately, thirty studies met the inclusion criteria and were selected for data extraction and quantitative analysis<sup>24–53</sup>. The detailed article screening process is presented in Fig. 1.

### Characteristics of the included studies

The included articles comprised a total of 29,904 patients, with 18,535 assigned to the intervention groups and 11,369 to the control groups. Outcomes were reported as follows: thirty articles provided data on HbA<sub>1c</sub>, twelve on 2h-PPG, twenty on FPG, fifteen on TC, thirteen on HDL, sixteen on LDL and TG, and eleven on BMI. The detailed baseline characteristics are presented in Table 1.

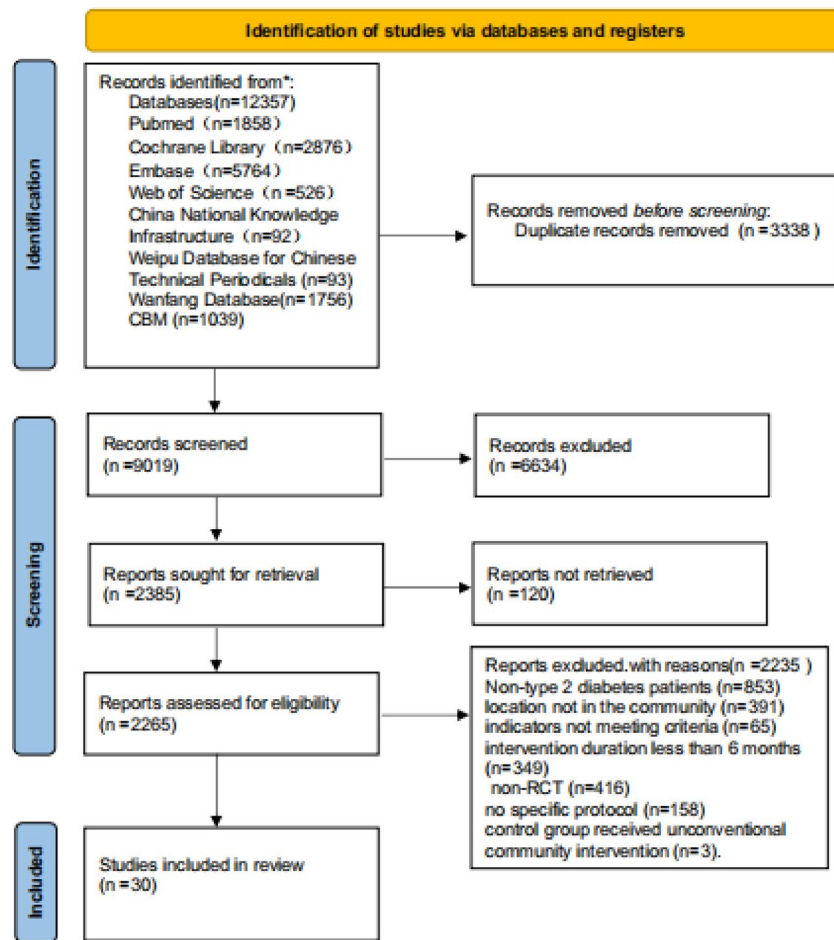


Fig. 1. PRISMA flowchart.

### Quality appraisal

The details of the assessment are presented in Fig. 2. Among the included studies, 26 studies reported the method used to generate random sequences, while four articles<sup>43–45,47</sup> were judged to have an unclear risk of bias due to insufficient reporting on randomization procedures. Only five articles<sup>32,42,48,51,52</sup> explicitly mentioned allocation concealment; the remaining studies did not provide specific information, resulting in an unclear risk of bias for this domain. Regarding blinding of participants and investigators, ten articles<sup>25,26,30,41–43,46,50–52</sup>, were assessed as having a high risk of bias due to the absence of blinding measures, whereas the remaining studies did not specify whether blinding was implemented, leading to an unclear risk classification. Concerning blinding of outcome assessment, only five articles<sup>45,46,49,52,53</sup>, clearly stated that outcome assessors were blinded, and were therefore rated as low risk; the rest provided no relevant information, resulting in an unclear risk of bias. With regard to incomplete outcome data, five studies<sup>31,32,34,38,39</sup>, reported participant dropout rates but failed to describe how missing data were handled, thus being classified as unclear risk of bias. In terms of selective outcome reporting, all studies were judged to be at low risk, as there was no evidence of selective reporting. Finally, the assessment of other potential biases indicated a low risk across all included studies.

### Primary outcomes

HbA<sub>1c</sub> was used as an outcome measure in all 30 studies<sup>24–53</sup>, encompassing a total of 29,904 participants. There was substantial heterogeneity among the studies ( $I^2=91\%$ ), thus a random-effects model was applied for the meta-analysis. The results indicated that the intervention group achieved a significantly greater reduction in HbA<sub>1c</sub> levels compared to the control group ( $MD=-0.57$ , 95%  $CI=-0.69$  to  $-0.45$ ,  $P<0.00001$ ; 95% Prediction Interval:  $-1.23$  to  $0.08$ ) (Fig. 3). This meta-analysis demonstrates that community-based interventions are associated with a statistically significant and clinically meaningful reduction in HbA<sub>1c</sub> levels.

A total of 12 studies<sup>24–27,29,31,33–37,53</sup>, included 2h-PPG level as an outcome measure, involving 2908 participants. Significant heterogeneity was observed across the studies ( $I^2=88\%$ ), and therefore a random-effects model was employed for the meta-analysis. The results indicated that the intervention group achieved a significantly greater improvement in 2h-PPG levels compared with the control group compared to the control group ( $MD=-1.68$ , 95%  $CI=-2.24$  to  $-1.12$ ,  $P<0.00001$ ; 95% Prediction Interval:  $-3.65$  to  $0.29$ ) (Fig. 4). These findings indicate a robust improvement in postprandial glucose control following the implementation of community management models.

References	Country	Sample size, n(intervention/control)	Age	Intervention (type, duration, frequency)	Comparison	Management style	Outcomes
Shen <sup>36</sup>	China	I:93/ C:96	I:18–75/ C:18–75	Personalized service package, with follow-up visits every 3 days before blood glucose levels are met, and monthly visits thereafter, for a total of 9 months	National Public Health Service Package Management	Led by the family doctor team, in collaboration with health nurses, nutritionists, and social (volunteer) workers, providing personalized diagnosis, treatment, and follow-up management	①②③④⑤⑥⑦
Ben <sup>24</sup>	China	I:68/ C:69	I:58.92 ± 7.60/ C:59.18 ± 7.74	“Internet + ”Health Management Platform, weekly data upload and regular follow-ups, 12 months	Routine management	Family doctor team online (APP/ WeChat interaction) combined with offline (on-site diagnosis and treatment), smart devices real-time monitoring data feedback	①②③④⑤⑥⑦⑧
Peng <sup>34</sup>	China	I:54/ C:48	I:36–68/ C:36–68	Internet-based health education, including website video lectures (once/week), WeChat public account posts (2–3 times/week), and peer education groups (2–3 times/month), for a total of 6 months	Conventional health education	Multidisciplinary team (physicians, nurses, peer educators) combining online and offline approaches, providing personalized health guidance	①②③④⑤⑥⑦
Wang <sup>37</sup>	China	I:60/ C:60	I:58.6 ± 6.3/ C:60.8 ± 7.4	Internet of Things Technology Management, portable blood glucose meter and cloud platform, 6 months	Routine diabetes management	Community doctor remote monitoring, smart device automatic reminders, online health guidance	①②③④⑤⑥⑦⑧
Huang <sup>29</sup>	China	I:100/ C:100	I:59.25 ± 3.57/ C:59.29 ± 3.56	Traditional Chinese Medicine holistic management, 12 months	Conventional management	Integrated Chinese and Western Medicine team to develop personalized plans, focusing on overall balance and complication prevention	①②③⑦
Luo <sup>33</sup>	China	I:60/ C:60	I:45 ~ 75/ C:45 ~ 75	Enhanced blood glucose monitoring by family doctors, weekly glucose testing at the studio for 6 months	Routine follow-up	One-on-one high-frequency monitoring by family doctors, combined with dietary and exercise guidance	①②③④⑤⑥⑦⑧
Zhang <sup>39</sup>	China	I:72/ C:72	I:61.69 ± 8.02/ C:59.33 ± 8.34	Self-management group activities, once a week for 6 months	Routine management	Patient self-management group supported by community doctors, led by group leaders in learning and practice	①③④⑤⑥⑦⑧
Ren <sup>35</sup>	China	I:53/ C:52	I:56.3 ± 15.0 C:57.1 ± 15.3	Family doctor individualized strategies, developing personalized plans, bi-weekly telephone follow-ups, monthly follow-ups for 6 months	Routine management	Family doctor team-led, one-on-one personalized management, developing plans based on patient lifestyle and condition	①②③
Liu <sup>32</sup>	China	I:76/ C:68	I:18–75/ C:18–75	Peer support intervention (standardized diabetes management and peer support group activities) for 36 months	Standardized diabetes management	Community doctors train group leaders, patient-led group interactions (knowledge learning, experience sharing, problem-solving)	①③
Li <sup>31</sup>	China	I:123/ C:125	I:57–81/ C:57–81	Systematic self-management education (classroom education, once a month for the first 12 months; bi-monthly telephone follow-ups for the last 6 months), for 18 months	Routine community education	Multiform education combining (special lectures, group discussions, telephone follow-up support)	①②③
Li <sup>30</sup>	China	I:60/ C:60	I:59.29 ± 15.4/ C:59.29 ± 15.4	Group interactive management (divided into 3 groups, with quarterly patient-patient/nurse-patient interaction sessions), lasting 18 months	Routine self-management	Specialist nurses organize group interactions, providing on-site guidance and personalized advice	①③

Continued

References	Country	Sample size, n(intervention/control)	Age	Intervention (type, duration, frequency)	Comparison	Management style	Outcomes
Fan <sup>27</sup>	China	I:100/ C:100	I:63.5 ± 5.9/ C:63.6 ± 6.0	Family physician refined management (outpatient personalized guidance, quarterly HbA <sub>1c</sub> monitoring), for 12 months	Traditional management (public health physician quarterly follow-up)	Family physician contract system, targeted health education and follow-up	①②③
Gong <sup>28</sup>	China	I:179/ C:184	I:61.9 ± 7.1/ C:62.2 ± 9.2	Remote Blood Glucose Management System (Home glucose meter uploads data in real time, 4 times per week for the first 3 months, 2 times per week from 4 to 6 months, and once per week from 7 to 12 months)	Routine Blood Glucose	Management Community and tertiary hospital collaboration, remote real-time monitoring and SMS guidance	①③④⑤⑥⑦
Cai <sup>25</sup>	China	I:500/ C:500	I:66.5 ± 6.4/ C:65.9 ± 6.5	Traditional Chinese Medicine (TCM) characteristic health education (syndrome differentiation and treatment + TCM dietary/exercise/psychological guidance), lasting 10 months	Conventional drug therapy and oral health education	Individualized intervention guided by TCM theory (syndrome differentiation, seasonal health maintenance, dietary regulation)	①②③④⑤⑥⑦⑧
Shen <sup>26</sup>	China	I:150/ C:150	I:62.6 ± 10.2/ C:62.8 ± 10.5	The five-in-one approach of Traditional Chinese Medicine (TCM) syndrome differentiation and constitution identification + health education + constitution regulation + meridian dredging + seasonal sequence), lasting 12 months	Regular family doctor contracted services	The family doctor team integrates TCM theory to provide syndrome differentiation treatment, seasonal health maintenance, medicinal diet regulation, and meridian therapy	①②③④⑤⑥⑦⑧
Yu <sup>38</sup>	China	I:426/ C:394	I:67.62 ± 11.31 C:68.27 ± 12.47	Mobile healthcare APP intervention, blood glucose monitoring ≥ 3 times/day, ≥ 3 days/week, for 6 months;	Routine community intervention	Community doctors remotely monitor via APP, adjust medication and provide lifestyle guidance in real-time	①③⑦
Davies <sup>40</sup>	UK	I:437/ C:387	I:59.9 ± 8.4 C:60.2 ± 8.7	Structured group education, emphasizing behavior change, medication management, etc., for 12 months	Routine care	Each site has a local coordinator to oversee the trial, with primary care institutions collaborating with the research team to ensure intervention consistency	①④⑤⑥⑦
Debussche <sup>41</sup>	Mali	I:70/ C:70	I:53.9 ± 9.8 C:51.1 ± 9.6	Peer-led structured patient education, 3 sessions, each consisting of 4 group meetings, totaling 12 months	Routine care	Community health workers: Train 5 peer educators to provide culturally tailored group education focusing on diet, exercise, blood glucose management, etc	①⑧
Deng <sup>53</sup>	China	I:90/ C:97	I:56.34 ± 7.94 C:57.51 ± 5.96	Peer support training, with the first 3 months dedicated to traditional training and the subsequent 4 months to peer support, totaling 7 months	Traditional training and follow-up	Community nurses collaborate with peer supporters: nurses train peer supporters, providing personalized telephone consultations and group activities	①③④⑥⑦⑧
Jia <sup>42</sup>	China	I:13,037/ C:6509	I:60.5 ± 8.4/ C:60.5 ± 8.4	mHealth stratified diabetes management intervention, including monthly blood glucose monitoring, quarterly performance evaluation, and mobile health platform support, lasting for 12 months	Routine care, basic public health services;	Tertiary hospital and community linkage: primary care physicians monitor in real-time through the mobile platform, with remote support provided by higher-level hospitals	①③⑥
Kim <sup>43</sup>	USA	I:105/ C:104	I:58.7 ± 8.4/ C:58.7 ± 8.4	Multimodal intervention, 12-h group education and monthly telephone consultation, for a total of 12 months	Baseline education manual	Bilingual nurse and community health worker team: providing culturally tailored education, blood glucose monitoring guidance, and psychological support	①④⑤⑥⑦

Continued

References	Country	Sample size, n(intervention/control)	Age	Intervention (type, duration, frequency)	Comparison	Management style	Outcomes
Kong <sup>44</sup>	China	I:134/ C:124	I:69.12 ± 10.54 C:71.48 ± 8.79	Chronic care model intervention, including health system, self-management support, decision support, etc., for a total of 9 months	Routine care	Community health service center team: multidisciplinary team collaboration, personalized management based on the CCM framework	①③④⑤⑥⑦⑧
Lynch <sup>45</sup>	USA	I:97/ C:99	I:55.0 ± 10.3/ C:55.0 ± 10.3	LIFE intervention, 28 group sessions and peer supporter telephone follow-ups, for a total of 18 months	Standard care	Registered dietitian and peer supporter: culturally tailored diet and exercise education, group interaction, and self-monitoring guidance	①
Perez-Escamilla <sup>46</sup>	USA	I:105/ C:106	I:55.46 ± 11.5 C:57.36 ± 12.1	Community health worker-led home intervention with 17 home visits over 12 months	Standard care	Community health workers collaborate with the medical team: providing culturally tailored family education and coordinating medical resources	①③④⑥⑦⑧
Presley <sup>47</sup>	USA	I:62/ C:35	I:54.6 ± 8.2 C:55.8 ± 8.5	Self-management education and mobile health peer support for 6 months	Community self-management intervention alone	Community health workers communicate with the medical team through mobile applications to provide behavioral goal support and emotional support	①
Sherifali <sup>48</sup>	Canada	I:233/ C:232	I:62 ± 11/ C:62 ± 10	Computer-generated customized feedback, regular feedback based on questionnaire results, for a total of 12 months	Standardized community services	Community project coordination: providing personalized advice via email and phone, linking with primary care physicians	①
Simmons <sup>49</sup>	UK	I:781/ C:283	I:65 ± 9/ C:63 ± 10	Group/individual peer support, monthly nurse support meetings and structured education, for 12 months	Routine care	Peer support: Training PSF to provide non-directive support, focusing on life management and emotional support	①④
Spencer <sup>50</sup>	USA	I:72/ C:92	I:50/ C:55	Community health worker intervention, group sessions + monthly home visits + clinic accompaniment, for 6 months	Routine care	Family health advocates: culturally tailored education, family support based on empowerment theory	①⑥⑧
Tang <sup>51</sup>	Canada	I:98/ C:98	I:60.5 ± 11.4 C:58.5 ± 10.9	Peer support intervention, weekly telephone contact for 3 months, bi-weekly telephone contact for 9 months, totaling 12 months	Routine care	Peer leaders: trained for 30 h, providing telephone support, assisting in setting self-management goals, problem-solving, and emotional support	①⑧
Zhang <sup>52</sup>	China	I:1038/ C:1034	I:61.4 ± 7.1/ C:61.6 ± 6.9	Multidimensional digital health intervention, Patient/Family Health Promoter application and clinical decision support, for 24 months	Routine primary care	Digital platform and family support: FHP assists in self-management, physicians remotely monitor, government-led quality improvement	①③④⑥⑦⑧

**Table 1.** Characteristics of included studies. I = Intervention group, C = Control group, ① HbA<sub>1c</sub>, ② 2-h postprandial blood glucose, ③ Fasting blood glucose, ④ Total cholesterol, ⑤ High-density lipoprotein, ⑥ Low-density lipoprotein, ⑦ Triglycerides, ⑧ Body mass index.

There were 20 studies<sup>24–39,42,44,46,52</sup>, that included FPG as an outcome measure, involving a total of 26,586 participants. Substantial heterogeneity was observed across the studies ( $I^2 = 82\%$ ), and therefore a random-effects model was used for the meta-analysis. The results indicated that the intervention group showed significantly greater improvement in FPG levels compared to the control group ( $MD = -0.98$ , 95%  $CI = -1.16$  to  $-0.79$ ,  $P < 0.00001$ ; 95% Prediction Interval:  $-2.02$  to  $0.04$ ) (Fig. 5). Community interventions therefore also confer a significant benefit on fasting glycemia. Thus, community-based management appears to have a modest but significant positive impact on total cholesterol.

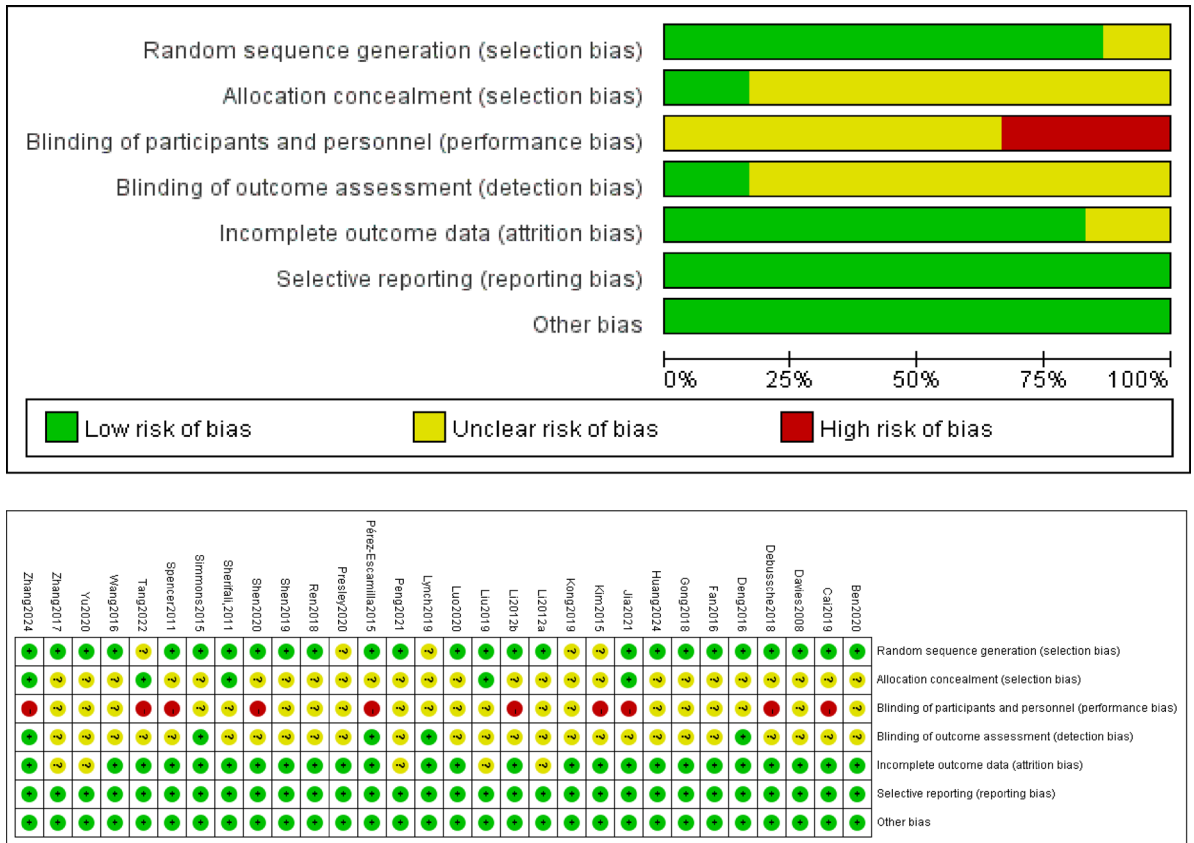


Fig. 2. Risk of bias (ROB) assessment (A) ROB summary. (B) ROB graph.

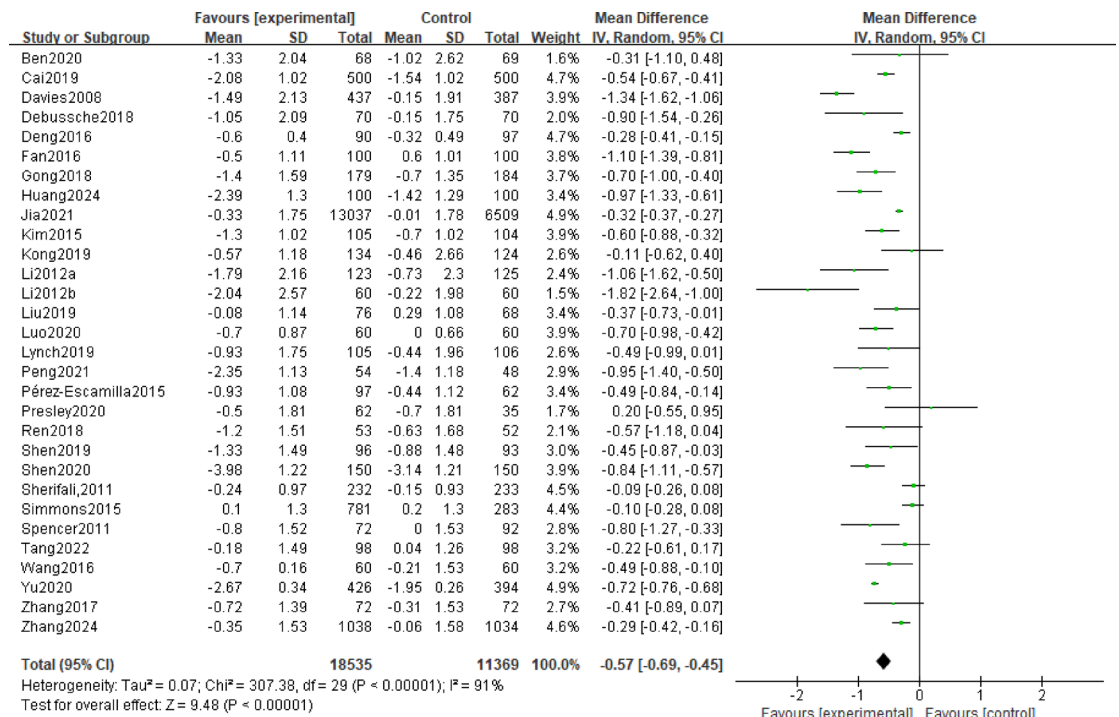
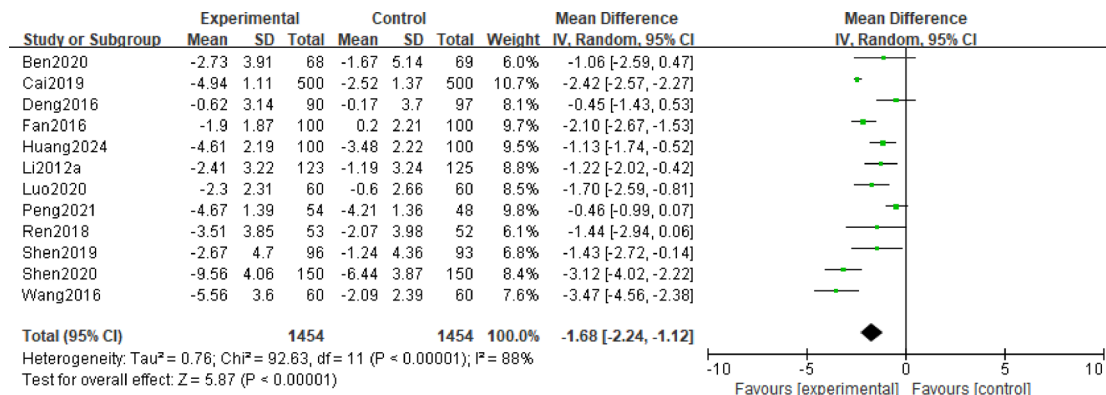
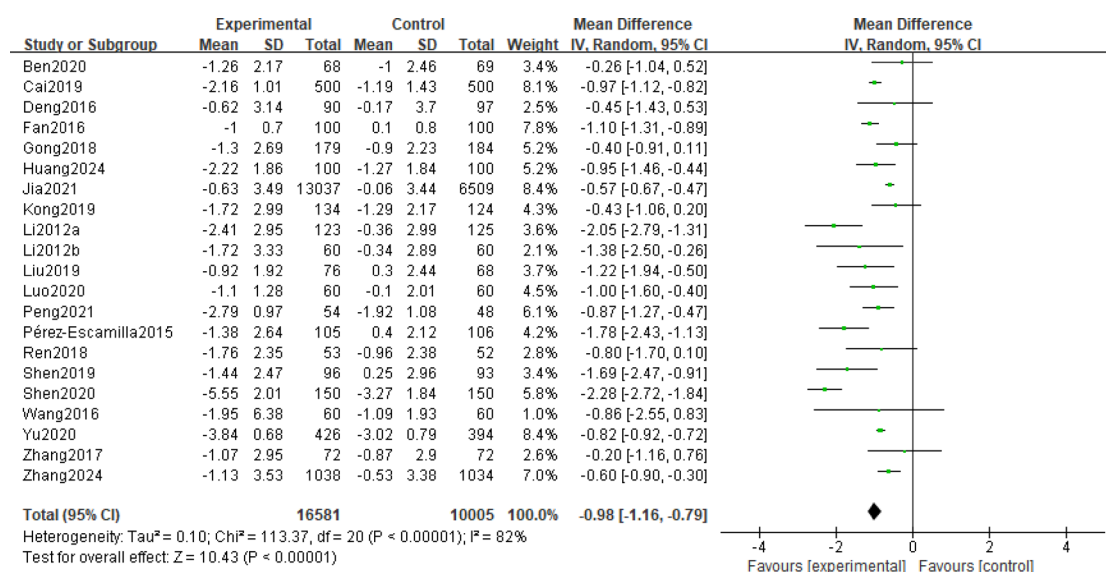


Fig. 3. Meta-analysis forest plot comparing HbA<sub>1c</sub> levels between the intervention group and the control group.



**Fig. 4.** Meta-analysis forest plot comparing postprandial 2 h-PPG levels between the intervention group and the control group.



**Fig. 5.** Meta-analysis forest plot comparing FPG levels between the intervention group and the control group.

**Secondary results**

A total of 15 studies<sup>24–26,28,33,34,36,37,39,40,43,44,46,49,53</sup>, included TC as an outcome measure, encompassing 5228 participants in total. High heterogeneity was observed across these studies (I<sup>2</sup> = 93%), so a random-effects model was employed for the meta-analysis. The results indicated that the improvement in TC levels in the intervention group was significantly greater than that in the control group (MD = -0.33, 95% CI = -0.54 to -0.11, P = 0.003; 95% Prediction Interval: -1.44 to 0.77) (Fig. 6). Thus, community-based management appears to have a modest but significant positive impact on total cholesterol.

Among the 13 studies<sup>24–26,28,33,34,36,37,39,40,43,44,46</sup>, that included HDL as an outcome measure, a total of 3977 participants were analyzed. Significant heterogeneity was observed across the studies (I<sup>2</sup> = 92%), thus a random-effects model was employed for the meta-analysis. The results indicated that the improvement in HDL levels in the intervention group was not statistically significant (MD = 0.06, 95% CI = -0.01 to 0.13, P = 0.09; 95% Prediction Interval: -0.28 to 0.40) (Fig. 7). In summary, the intervention did not lead to a statistically significant improvement in HDL cholesterol levels.

A total of 16 studies<sup>24–26,28,33,34,36,37,39,40,42–44,46,50,52</sup>, included LDL as an outcome measure, involving 25,706 participants in total. High heterogeneity was observed across these studies (I<sup>2</sup> = 100%), so a random-effects model was employed for the meta-analysis. The results indicated that the improvement in LDL levels in the intervention group was not statistically significant (MD = -0.33, 95% CI = -0.94 to 0.28, P = 0.29; 95% Prediction Interval: -1.08 to 1.01) (Fig. 8). Overall, no significant effect of community interventions on LDL cholesterol was observed.

A total of 16 studies<sup>24–26,28,29,33,34,36–40,43,44,46,52</sup>, reported TG levels as an outcome measure, encompassing 5184 participants in total. Substantial heterogeneity was observed across these studies (I<sup>2</sup> = 98%), thus a random-effects model was applied for the meta-analysis. The results indicated that the improvement in TG levels in

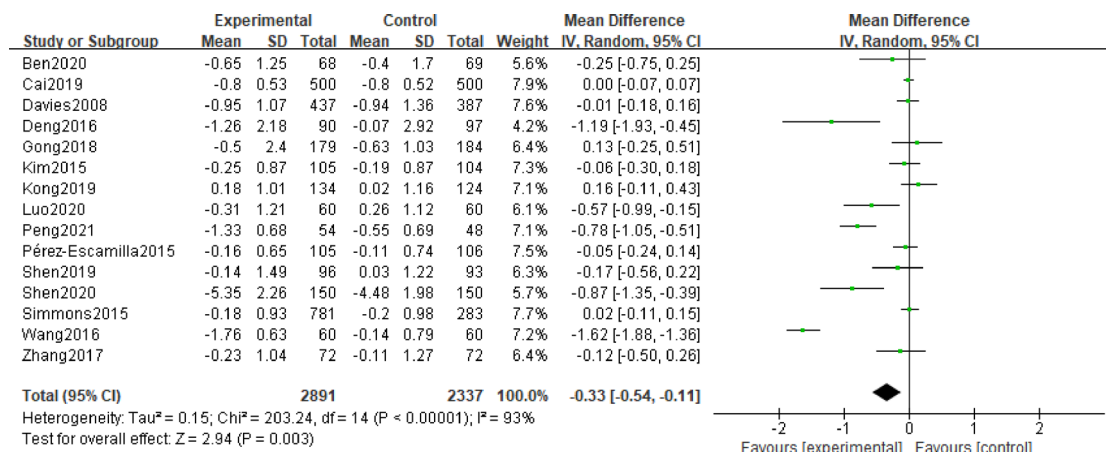


Fig. 6. Meta-analysis forest plot comparing TC levels between the intervention group and the control group.

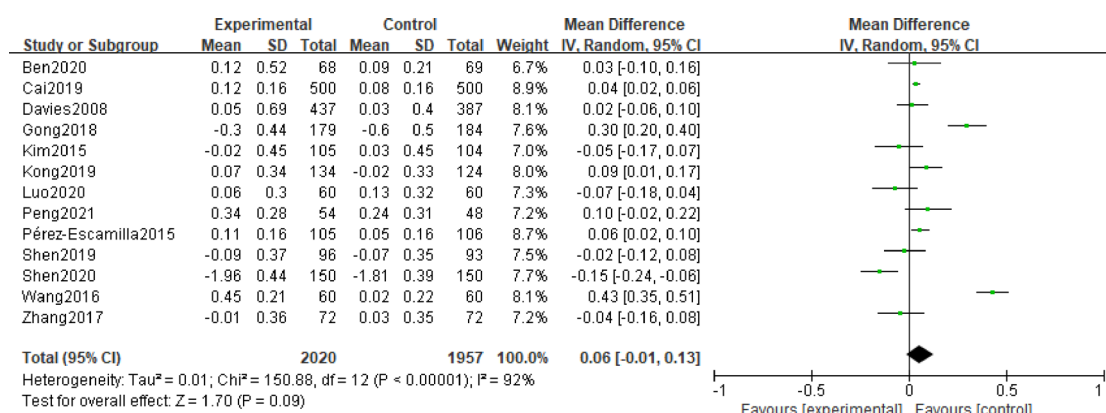


Fig. 7. Meta-analysis forest plot comparing HDL levels between the intervention group and the control group.

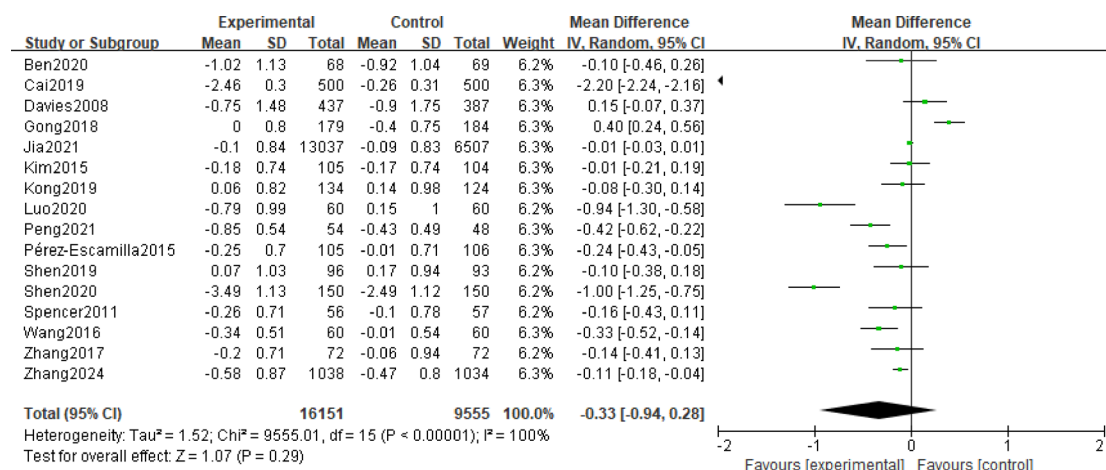
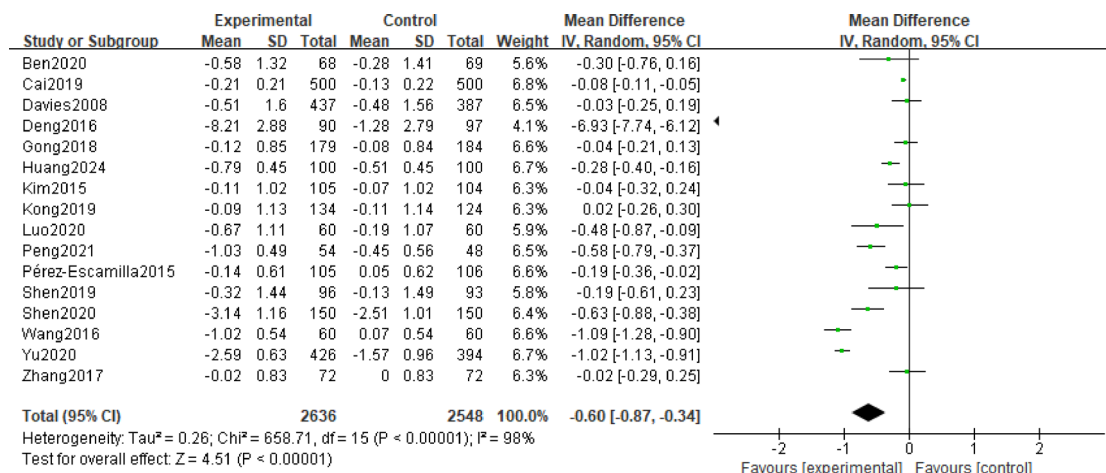


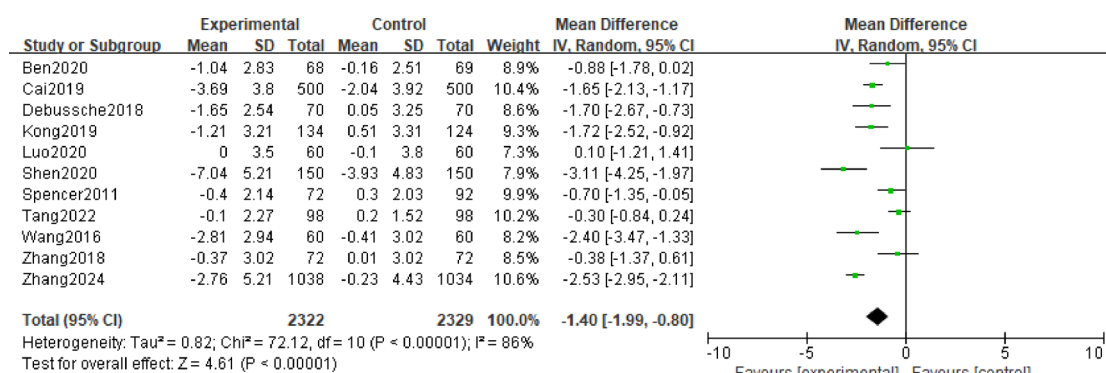
Fig. 8. Meta-analysis forest plot comparing LDL levels between the intervention group and the control group.

the intervention group was significantly greater than that in the control group ( $MD = -0.60, 95\% CI = -0.87$  to  $-0.34, P < 0.00001$ ; 95% Prediction Interval:  $-4.23$  to  $2.79$ ) (Fig. 9). This represents a significant reduction in triglyceride levels, suggesting a favorable effect on this key aspect of lipid profile.

Eleven studies<sup>24–26,33,37,39,41,44,50–52</sup>, included BMI as an outcome measure, involving a total of 2766 participants. Considerable heterogeneity was observed across the studies ( $I^2 = 86\%$ ), and therefore a random-



**Fig. 9.** Meta-analysis forest plot comparing TG levels between the intervention group and the control group.



**Fig. 10.** Meta-analysis forest plot comparing BMI between the intervention group and the control group.

effects model was employed for the meta-analysis. The results indicated that the improvement in BMI in the intervention group was significantly greater than that in the control group ( $MD = -1.40$ , 95%  $CI = -1.99$  to  $-0.80$ ,  $P < 0.00001$ ; 95% Prediction Interval:  $-3.33$  to  $0.63$ ) (Fig. 10). The findings support that community management models are effective in achieving a statistically significant reduction in body mass index.

### Subgroup analysis

#### Different implementing entities

Subgroup analyses were conducted according to the implementing entities—specifically, healthcare professionals versus non-healthcare professionals. The results indicated that FPG, TC, HDL, LDL, TG and BMI levels were not significantly influenced by the type of implementing entity (subgroup difference  $P$ -values: 0.98, 0.34, 0.47, 0.62, 0.06 and 0.18, respectively). However, the implementing entity had a differential impact on HbA<sub>1c</sub>. Compared with interventions led by non-healthcare personnel, those led by healthcare professionals demonstrated more significant improvements ( $P < 0.05$ ). Interventions conducted by healthcare personnel also resulted in a significant reduction in 2h-PPG levels. However, the inclusion of only one study in the non-healthcare personnel group precluded a reliable assessment of the true difference in impact on this indicator based on the implementing entity. To maintain homogeneity within subgroups regarding implementation entities, two studies were excluded from the analysis as they reported involvement from both healthcare and non-healthcare professionals, as detailed in Table 2. (Supporting Information 9).

#### Different intervention methods

Subgroup analysis based on intervention type (peer support vs. non-peer support) revealed that non-peer support interventions had a significantly greater effect on HbA<sub>1c</sub> levels (subgroup difference  $P < 0.00001$ ), particularly in relation to blood glucose and BMI. Only one study included postprandial 2-hPPG, HDL, and LDL as companion measures, which renders it impossible to reliably assess the true differences in the effects of the intervention methods on these indicators. For other blood glucose, lipid markers and BMI, improvements did not show significant variation according to the intervention method. To maintain subgroup homogeneity, three studies employing mixed interventions that included peer support were excluded from this analysis, as detailed in Table 3. (Supporting Information 9).

Outcome	Number of RCTs	Heterogeneity		Meta analysis		Subgroup differences
		P value	I <sup>2</sup> (%)	Effect estimate (95%CI)	P value	
HbA <sub>1c</sub> (%)	28 <sup>24-33,35-42,44-53</sup>	<0.00001	91	-0.56(-0.68,-0.44)	<0.00001	0.0002
Healthcare professionals	17 <sup>24-31,33,35-38,40,42,44,52</sup>	<0.00001	93	-0.69(-0.85,-0.54)	<0.00001	
Non-healthcare professionals	11 <sup>32,39,41,45-51,53</sup>	0.03	51	-0.30(-0.44,-0.17)	<0.0001	
2h-PPG(mmol/L)	11 <sup>24-27,29,31,33,35-37,53</sup>	<0.00001	81	-1.82(-2.32,-1.33)	<0.00001	0.0007
Healthcare professionals	10 <sup>24-27,29,31,33,35-37</sup>	<0.0001	77	-1.96(-2.43,-1.49)	<0.00001	
Non-healthcare professionals	1 <sup>53</sup>			-0.45(-1.43,0.53)	0.37	
FPG(mmol/L)	19 <sup>24-33,35-39,42,44,46,52</sup>	<0.00001	83	-0.99(-1.18,-0.79)	<0.00001	0.98
Healthcare professionals	16 <sup>24-31,33,35-38,42,44,52</sup>	<0.00001	85	-0.97(-1.18,-0.77)	<0.00001	
Non-healthcare professionals	4 <sup>32,39,46,53</sup>	0.02	68	-0.98(-1.70,-0.26)	0.007	
TC(mmol/L)	13 <sup>24-26,28,32,33,36,37,39,40,44,46,49</sup>	<0.00001	93	-0.31(-0.55,-0.08)	<0.00001	0.34
Healthcare professionals	9 <sup>24-26,28,33,36,37,40,44</sup>	<0.00001	95	-0.45(-0.71,0.01)	0.06	
Non-healthcare professionals	4 <sup>32,39,46,49</sup>	0.02	71	-0.14(-0.38,0.11)	0.27	
HDL(mmol/L)	11 <sup>24-26,28,33,36,37,39,40,44,46</sup>	<0.00001	93	0.07(-0.01,0.14)	0.10	0.47
Healthcare professionals	9 <sup>24-26,28,33,36,37,40,44</sup>	<0.00001	94	0.08(-0.03,0.18)	0.14	
Non-healthcare professionals	2 <sup>39,46</sup>	0.11	60	0.03(-0.07,0.12)	0.60	
LDL(mmol/L)	14 <sup>24-26,28,33,36,37,39,40,42,44,46,50,52</sup>	<0.00001	100	-0.35(-1.01,0.32)	0.30	0.62
Healthcare professionals	11 <sup>24-26,28,33,36,37,40,42,44,52</sup>	<0.00001	100	-0.39(-1.16,0.37)	0.31	
Non-healthcare professionals	3 <sup>39,46,50</sup>	0.80	0	-0.20(-0.33,-0.06)	0.005	
TG(mmol/L)	14 <sup>24-26,28,29,33,36-40,44,46,53</sup>	<0.00001	98	-0.65(-0.94,-0.36)	<0.00001	0.06
Healthcare professionals	11 <sup>24-26,28,29,33,36-38,40,44</sup>	<0.00001	97	-0.38(-0.65,-0.11)	0.006	
Non-healthcare professionals	3 <sup>39,46,53</sup>	<0.00001	99	-2.30(-4.30,-0.31)	0.002	
BMI(Kg/m <sup>2</sup> )	11 <sup>24-26,33,37,39,41,44,50,51,53</sup>	<0.00001	78	-1.34(-1.88,-0.81)	<0.00001	0.18
Healthcare professionals	6 <sup>24-26,33,37,44</sup>	0.003	72	-1.63(-2.32,-0.95)	<0.00001	
Non-healthcare professionals	5 <sup>39,41,50,51,53</sup>	0.01	70	-0.97(-1.65,-0.29)	0.005	

**Table 2.** Results of subgroup analysis based on different implementing entities.

## Investigation of heterogeneity and sensitivity analyses

### Meta-regression

To further investigate the high heterogeneity observed in the meta-analysis, univariate random-effects meta-regression analyses were conducted on a series of covariates, including baseline levels, intervention duration, sample size, mean patient age, the study's geographic location (specifically whether it was conducted in China), and the mode of intervention delivery. The results indicate that the sources of heterogeneity vary across outcome measures. Specifically, baseline TG levels emerged as a highly significant determinant of effect size ( $\beta = -0.634$ ,  $P < 0.001$ ), explaining up to 87.22% of the variation between studies. For TC, the effect size was similarly significantly influenced by its baseline level ( $\beta = -0.191$ ,  $P = 0.044$ ), while study sample size also emerged as a significant factor ( $\beta = 0.335$ ,  $P = 0.045$ ). In a subgroup analysis specific to 2 h-PPG, a significant negative correlation was observed between mean patient age and effect size ( $\beta = -0.094$ ,  $P = 0.048$ ). However, none of the aforementioned covariates demonstrated statistically significant associations with other primary outcome measures including LDL, HDL, BMI, HbA<sub>1c</sub>, or FPG. In summary, this exploratory analysis successfully identified partial sources of heterogeneity in TG, TC, and 2 h-PPG. Nevertheless, the high heterogeneity observed in the remaining indicators remains primarily attributable to other complex factors not measured in this study. (Supporting Information 5).

### Sensitivity analysis

Sensitivity analyses were conducted by sequentially excluding individual studies. Following the removal of studies contributing to heterogeneity, the intervention effects across all outcomes remained largely unchanged compared to the original analysis, suggesting the robustness and reliability of the results (Supporting Information 4). To test the robustness of the conclusions derived from the primary subgroup analyses—comparing different implementing bodies and intervention methods—we conducted a sensitivity analysis by reclassifying and including studies with mixed intervention models that were initially excluded based on the 'predominant lead' rule. The results indicated that the key subgroup differences remained stable. (Supporting Information 7) To evaluate the generalizability of the study findings beyond the Chinese context, we performed a sensitivity analysis that included only ten international studies. Regarding the primary outcome measure, the analysis demonstrated that community interventions still had a significant effect on improving glycated hemoglobin ( $MD = -0.49$ , 95% CI [-0.78, -0.20]), which aligns with the conclusions of the main analysis. For the secondary outcome measures, the results exhibited divergence. While the improvement in body mass index remained significant, the enhancements in total cholesterol ( $MD = -0.01$ , 95% CI [-0.10, 0.07]) and triglycerides ( $MD = -0.11$ , 95% CI [-0.23, 0.00]) were no longer statistically significant. Due to the limited number of studies

Outcome	Number of RCTs	Heterogeneity		Meta analysis		Subgroup differences
		P value	I <sup>2</sup> (%)	Effect estimate (95%CI)	P value	
HbA <sub>1c</sub> (%)	27 <sup>24-29,31-33,35-44,46-53</sup>	<0.00001	91	-0.54(-0.66,-0.42)	<0.00001	0.0003
Peer support	7 <sup>32,39,41,47,49,51,53</sup>	0.16	35	-0.26(-0.40,-0.11)	0.0005	
Non-peer support	20 <sup>24-29,31,33,35-38,40,42-44,46,48,50,52</sup>	<0.00001	92	-0.62(-0.76,-0.48)	<0.00001	
2h-PPG(mmol/L)	11 <sup>24-27,29,31,33,35-37,53</sup>	<0.00001	81	-1.82(-2.32,-1.33)	<0.00001	0.007
Peer support	1 <sup>53</sup>			-0.45(-1.43,0.53)	0.37	
Non-peer support	10 <sup>24-27,29,31,33,35-37</sup>	<0.00001	77	-1.96(-2.43,-1.49)	<0.00001	
FPG(mmol/L)	18 <sup>24-29,31-33,35-39,42,44,46,52</sup>	<0.00001	74	-0.88(-1.04,-0.71)	<0.00001	0.57
Peer support	3 <sup>32,39,53</sup>	0.20	39	-0.69(-1.34,-0.05)	0.04	
Non-peer support	16 <sup>24-29,31,33,35-38,42,44,46,52</sup>	<0.00001	77	-0.89(-1.06,-0.72)	<0.00001	
TC(mmol/L)	14 <sup>24-26,33,36,37,39,40,43,44,46,49,53</sup>	<0.00001	93	-0.29(-0.51,-0.07)	0.009	0.98
Peer support	3 <sup>39,49,53</sup>	0.006	81	-0.30(-0.78,0.19)	0.23	
Non-peer support	11 <sup>24-26,33,36,37,40,43,44,46</sup>	<0.00001	94	-0.29(-0.56,-0.02)	0.04	
HDL(mmol/L)	12 <sup>24-26,28,33,36,37,39,40,43,44,46</sup>	<0.00001	93	0.06(-0.02,0.13)	0.10	0.14
Peer support	1 <sup>39</sup>			-0.04(-0.16,0.08)	0.50	
Non-peer support	11 <sup>24-26,28,33,36,37,40,43,44,46</sup>	<0.00001	93	0.06(-0.01,0.14)	0.10	
LDL(mmol/L)	15 <sup>24-26,28,33,36,37,39,40,42-44,46,50,52</sup>	<0.00001	100	-0.32(-0.96,0.31)	0.32	0.59
Peer support	1 <sup>39</sup>			-0.14(-0.41,0.13)	0.31	
Non-peer support	14 <sup>24-26,28,33,36,37,40,42-44,46,50,52</sup>	<0.00001	100	-0.34(-1.00,0.32)	0.32	
TG(mmol/L)	15 <sup>24-26,28,29,33,36-40,43,44,46,53</sup>	<0.00001	98	-0.61(-0.89,-0.33)	<0.00001	0.37
Peer support	2 <sup>39,53</sup>	<0.00001	100	-3.46(-10.24,3.31)	0.32	
Non-peer support	13 <sup>24-26,28,29,33,36-38,40,43,44,46</sup>	<0.00001	97	-0.34(-0.57,-0.11)	0.004	
BMI(Kg/m <sup>2</sup> )	11 <sup>24-26,33,37,39,41,44,50,51,53</sup>	<0.00001	78	-1.34(-1.88,-0.81)	<0.00001	0.53
Peer support	4 <sup>39,41,51,53</sup>	0.004	77	-1.11(-2.07,-0.15)	0.02	
Non-peer support	7 <sup>24-26,33,37,44,50</sup>	0.0004	76	-1.48(-2.11,-0.84)	<0.00001	

**Table 3.** Results of subgroup analysis according to different intervention methods.

reporting 2-h postprandial blood glucose ( $n=0$ ) and fasting blood glucose ( $n=1$ ) in international research, reliable conclusions could not be drawn regarding these outcomes. (Supporting Information 8).

### Certainty of evidence and publication bias

The certainty of the evidence was assessed using the GRADE criteria (Supporting Information 3). All outcomes were rated as having low certainty. This downgrade was primarily due to methodological limitations and substantial heterogeneity, which affected the domains of risk of bias and inconsistency, respectively. Publication bias was assessed through visual inspection of funnel plots and Egger's statistical test (Supporting Information 4, 6). Egger's test indicated no statistically significant evidence of small-study effects for any outcome ( $P > 0.05$ ), with the exception of TG, which showed potential publication bias ( $P < 0.05$ ). To further evaluate the robustness of the triglyceride findings in light of this potential bias, we conducted a trim-and-fill analysis. The results revealed that no studies needed to be imputed, and the pooled effect estimate remained unchanged ( $\text{exp}(ES) = 0.486$ , 95% CI: 0.221–1.068). This suggests that while statistical tests indicated potential publication bias for triglycerides, the actual impact on the pooled effect size appears to be minimal.

## Discussion

### Summary of key findings

This study, based on a meta-analysis of 30 RCTs conducted in the community, demonstrates that the community management model significantly improves levels of HbA<sub>1c</sub>, 2h-PPG, FPG, TC, TG, and BMI in patients with T2D. However, the model did not show statistical significance in improving HDL and LDL. Key findings from subgroup analysis provide new insights for optimizing resource allocation. Interventions led by medical professionals were significantly more effective in improving HbA<sub>1c</sub> levels compared to those led by non-medical professionals (subgroup difference  $P=0.0002$ ). Similarly, the non-peer support model was found to be more effective than the peer support model in reducing HbA<sub>1c</sub> levels (subgroup difference  $P=0.0003$ ).

### Comparison with prior literature

The findings of this study are consistent with the extensive body of literature that confirms the effectiveness of community management in glycemic control for patients with T2D<sup>20,54–57</sup>. Regarding lipid metabolism, the findings are consistent with those reported by White et al.<sup>55</sup>. However, existing evidence reveals notable inconsistencies; for example, Lee et al.<sup>54</sup> conducted a meta-analysis that identified a significant reduction in TG levels, yet no substantial improvements were observed in other lipid parameters. The Siang Joo Seah team<sup>58</sup> reported that LDL was the only parameter that did not demonstrate significant improvement, while all other lipid parameters were notably optimized. This inconsistency may arise from differences in the baseline metabolic status

of study participants or variations in the intervention protocols focusing on specific lipoproteins. Additionally, from a physiological mechanism perspective, insulin resistance enhances the activity of cholesterol ester transfer protein, leading to accelerated degradation of HDL particles, which may limit the effectiveness of lifestyle interventions on this parameter<sup>59</sup>. Therefore, from a clinical standpoint, the role of community management in comprehensively optimizing the atherogenic lipid profile is likely ancillary. Our findings underscore that to achieve comprehensive cardiovascular risk management in patients with T2D, effective community-based models must be integrated with necessary lipid-lowering pharmacotherapy. Most previous studies typically only validate the absolute efficacy of community interventions compared to routine care, or do not strictly differentiate between the implementing entities<sup>16,55</sup>. Through direct subgroup comparisons, this study provides quantitative evidence for the optimized allocation of resources regarding the relative effectiveness of “medical professionals versus non-medical professionals” and “peer support versus non-peer support” models.

### Interpretation of subgroup findings: implications for resource allocation

#### *Effectiveness of healthcare professionals and non-healthcare professionals*

The advantages of interventions by healthcare professionals are closely tied to their professional qualifications and clinical decision-making abilities. For example, physicians can dynamically adjust treatment goals based on factors such as patient age, comorbidities, and functional status, while conducting structured follow-ups in line with evidence-based guidelines. This enables the implementation of multidimensional interventions addressing physiological, psychological, and behavioral aspects<sup>60</sup>. These comprehensive management capabilities, rooted in extensive medical knowledge and clinical expertise, are essential for optimizing glycemic control and preventing complications. In contrast, models involving non-healthcare professionals demonstrate notable limitations in effectiveness. Although CHWs have been involved in diabetes care for decades, their training and support systems remain insufficient<sup>61</sup>. A review by the United States Agency for International Development<sup>62</sup> identified critical deficiencies in these training systems, including a lack of professional knowledge and skills, inadequate supervision, and the absence of standardized, mandatory certification and continuous oversight mechanisms. These deficiencies represent primary factors that hinder CHWs’ ability to provide high-quality services. This finding does not contradict but rather contextualizes the conclusions of prior literature<sup>63,64</sup>. Those studies established the absolute efficacy of peer support over passive usual care. The present analysis, by contrast, reveals its relative efficacy within a hierarchy of active strategies. The key explanatory factor is the nature of the comparator group. This clarifies that peer support’s advantage is most pronounced in resource-limited settings, while its benefit may be smaller when directly compared to professionally-led interventions.

#### *Effectiveness of peer support and non-peer support models*

The variability in the effectiveness of peer support models may stem from differences in their underlying mechanisms and the contextual conditions under which they are implemented. Peer support operates through experiential resonance and emotional connections, whereby peer educators share personal experiences, assist in problem-solving, set achievable goals, maintain regular interactions, and cultivate trust-based relationships. These strategies aim to stimulate patients’ intrinsic motivation by helping them identify their needs, develop a readiness for change, and experience a sense of emotional belonging. Consequently, this process can facilitate behavioral changes such as consistent medication adherence, healthier eating habits, and increased self-efficacy. However, the success of this mechanism in generating meaningful and sustained health improvements is heavily contingent upon the individual circumstances of the recipients.

The core mechanism of peer support assumes that patients possess favorable baseline conditions. For individuals facing severe economic hardship, complex health issues, or compromised physical and mental well-being, their immediate priorities often center on resolving survival crises or alleviating acute suffering. In such contexts, while peer-provided emotional support offers psychological relief, it often fails to result in significant improvements in health-related behaviors<sup>65</sup>. Enhancing the effectiveness of peer support may require incorporating ‘active ingredients’ such as structured training; closer integration with clinical teams; and the use of validated protocols. This may be a primary reason why peer support models are less effective compared to non-peer support models.

### Clinical and public health significance of modest effects

After establishing the relative effectiveness of different models, interpreting the practical significance of their effect sizes, particularly in the context of the uneven distribution of medical resources, emerges as another critical issue. The subgroup analysis revealed that while the effects of non-medical professional-led models and peer support models in reducing HbA<sub>1c</sub> were limited, with reductions of only 0.3% and 0.26% respectively, these outcomes still hold significant clinical relevance in specific contexts. Firstly, the ADA guidelines indicate that the relationship between HbA<sub>1c</sub> and microvascular complications is continuous and curvilinear. This implies that any reduction in HbA<sub>1c</sub>, regardless of how small, can lead to a corresponding decrease in the risk of complications<sup>66</sup>.

According to the risk model from the UKPDS study, a 0.3% reduction in HbA<sub>1c</sub> is associated with an estimated 6% reduction in the risk of diabetes-related mortality, 4% reduction in myocardial infarction, and 11% reduction in microvascular complications<sup>67</sup>. While this effect may appear modest at the individual level, it can translate into substantial public health benefits when applied across large populations. Second, in regions with limited medical resources, access to healthcare services is often constrained, and even a small improvement in glycemic control may have a meaningful impact on population health. For instance, when a patient’s HbA<sub>1c</sub> level is nearing the 8% threshold for accelerated complications, a reduction of 0.3% can help halt the worsening trend and alleviate the strain on scarce resources caused by acute complications. Furthermore, treatment targets should be individualized based on clinical factors such as age, duration of diabetes, complication risk, and life

expectancy. In elderly patients or those with advanced complications who are more vulnerable to hypoglycemia, glycemic goals may be appropriately relaxed. Hypoglycemia not only poses immediate health risks but is also linked to an increased likelihood of cardiovascular events and mortality. Interventions that achieve gradual and sustained reductions in HbA<sub>1c</sub> may therefore offer enhanced safety and long-term clinical benefit. In summary, although non-healthcare professional-led models and peer support initiatives demonstrate modest efficacy in lowering HbA<sub>1c</sub>, their clinical relevance and public health value in specific settings should not be overlooked<sup>66,68</sup>.

### Heterogeneity and context dependency

A paramount consideration in interpreting our findings is the substantial heterogeneity observed across most meta-analyses ( $I^2$  often > 90%). While this degree of variability is not uncommon in meta-analyses of complex, real-world community interventions, it necessitates caution in deriving definitive conclusions. This heterogeneity likely stems from a confluence of factors inherent to the included studies. These include variations in the specific components and intensity of the interventions, differences in the training and experience of the lay personnel delivering them, diverse demographic and clinical characteristics of the participant populations across studies, and variations in the standard of ‘usual care’ provided to control groups. We conducted extensive meta-regression and sensitivity analyses to explore these sources; however, as reported, we could only explain a portion of the heterogeneity for certain outcomes like TG and TC, while for others, such as HbA<sub>1c</sub>, the sources remain largely unexplained. Consequently, the pooled effect estimates should be viewed as a summary of a wide range of potential effects rather than a single, precise truth. The wide prediction intervals, particularly for HbA<sub>1c</sub>, underscore that the true effect in a new, similar setting could vary considerably. Despite this, the consistent direction of benefit across nearly all glycemic and metabolic outcomes strengthens the inference that community-based management is generally advantageous, even if the magnitude of benefit is context-dependent.

### Limitations

#### *Absence of cost-effectiveness evidence*

A key limitation of the evidence base is the absence of cost-effectiveness data. Given that a primary rationale for exploring alternative models is to alleviate substantial economic burdens, it is a critical gap that none of the included studies provided standardized economic outcome data. Consequently, our review cannot inform whether the modest clinical benefits of non-professional or peer-support models are achieved in a cost-efficient manner. This lack of economic evidence significantly hinders the practical decision-making for policymakers who must allocate limited healthcare resources.

#### *Limited generalizability beyond the Chinese context*

A paramount consideration in interpreting our findings is the predominance of studies conducted in China. This geographical concentration, while reflective of the substantial research activity in community diabetes management within China’s rapidly evolving primary healthcare system, poses a significant challenge to the generalizability of our results. Our sensitivity analysis, which excluded China-dominant studies, underscored this concern by revealing that the significant improvements in total cholesterol and triglycerides observed in the main analysis were not sustained in the international cohort (Supporting Information 8). This suggests that the lipid-lowering benefits of community management may be more context-dependent than the glycemic benefits, which remained robust for HbA<sub>1c</sub>.

Several features of the Chinese healthcare context may explain these differences. The strong, centralized structure of community health centers may facilitate the standardized implementation of interventions. Furthermore, the integration of Traditional Chinese Medicine principles, as seen in several included studies<sup>25,26,29</sup>, may contribute unique benefits not captured in Western models. Additionally, the baseline “usual care” in control groups within China might differ in intensity from that in other countries, potentially amplifying the relative effect of the interventions. Consequently, while our hierarchical model is likely conceptually transferable, the absolute magnitude of benefit, particularly for lipid parameters, should be extrapolated with caution to dissimilar healthcare settings.

#### *Methodological limitations and unexplained heterogeneity*

This study is subject to several methodological constraints: (1) There are significant methodological limitations; only a few studies explicitly reported allocation concealment, and most did not implement blinding, which may overestimate the intervention effects. (2) The quality of evidence for all outcome measures is low, primarily due to significant clinical heterogeneity and the aforementioned methodological limitations. (3) The sources of heterogeneity are complex. In addition to the identified factors, significant variations in training content, skill levels, and supervision intensity among non-medical professionals across different studies represent potential sources of confounding in subgroup comparisons, contributing to heterogeneity. (4) Some subgroups included only a limited number of studies, and these results should be viewed as preliminary indications that must be interpreted with caution; definitive conclusions such as ‘equivalent effect’ or ‘no effect’ should be avoided.

### Future directions

To strengthen the current evidence, future research should focus on specifically evaluating the efficacy of peer support on lipid outcomes in rigorously designed RCTs with adequate allocation concealment and blinding, validating the generalizability of lay models across diverse healthcare systems, and exploring the establishment of standardized training and certification frameworks. In addition, cost-effectiveness evaluations and safety monitoring must be incorporated as core components of the research agenda to provide a holistic assessment of these alternative implementation models.

## Conclusions

This meta-analysis demonstrates that community-based management can lead to improvements in key glycemic parameters, triglycerides, and BMI in patients with T2D, despite non-significant effects on HDL and LDL and low certainty of evidence (GRADE). The findings support a tiered implementation approach: healthcare professional-led interventions are superior, but in resource-limited settings, non-professional and peer-support models serve as valuable second-best alternatives, achieving clinically relevant mean HbA<sub>1c</sub> reductions of 0.30% and 0.26%, respectively.

## Data availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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### Competing interests

The authors declare no competing interests.

### Additional information

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