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Effect of Community-Based Integrated Care for Patients With Diabetes and Depression (CIC-PDD) in China: A Pragmatic Cluster-Randomized Trial

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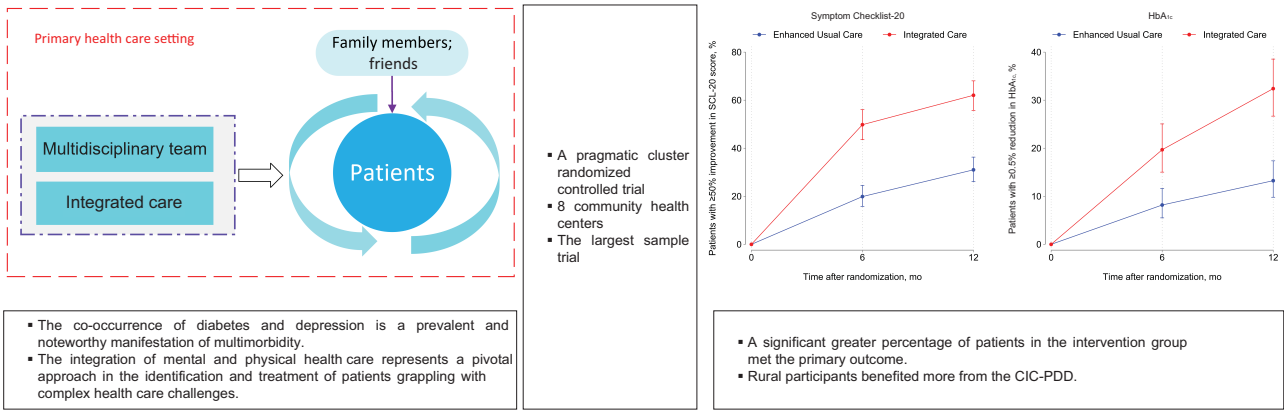

ARTICLE HIGHLIGHTS

- **Why did we undertake this study?**
  There remains a significant gap in our understanding of how to effectively identify and manage diabetes and depression multimorbidity within primary health care settings.
- **What are the specific questions we wanted to answer?**
  How can an integrated model be developed for patients with diabetes and depression in low- and middle-income countries, and is this care model effective?
- **What did we find?**
  In this well-powered cluster randomized controlled trial, the intervention group had significant improvements in mental health and HbA_{1c} compared with usual care. Participants from rural areas benefited more from the intervention.
- **What are the implications of our findings?**
  The community-based integrated care model for patients with diabetes and depression model enhances integrated care and addresses the critical need for accessible mental health resources in primary health care settings.

Effect of Community-Based Integrated Care for Patients With Diabetes and Depression (CIC-PDD) in China: A Pragmatic Cluster-Randomized Trial

Yanshang Wang,[1,2] Dan Guo,[3] Yiqi Xia,[1,2] Mingzheng Hu,[2] Ming Wang,[2] Qianqian Yu,[4] Zhansheng Li,[5] Xiaoyi Zhang,[5] Ruoxi Ding,[6] Miaomiao Zhao,[7,8] Zhenyu Shi,[1,2] Dawei Zhu,[9] and Ping He[2]

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OBJECTIVE

To develop a care model for patients with both diabetes and depression and assess the model's effectiveness.

RESEARCH DESIGN AND METHODS

In this pragmatic cluster randomized trial, we allocated eight community health centers into two groups: the enhanced usual care group and the intervention group. A comprehensive care plan was developed for the intervention group based on the integrated care model. We recruited individuals aged ≥18 years with type 2 diabetes and depression (Patient Health Questionnaire-9 score ≥10). The primary outcome was the between-group difference in the percentage of patients who had at least a 50% reduction in depressive symptoms and a reduction of at least 0.5 percentage points in HbA_{1c}. The outcome analysis was conducted within the intention-to-treat population; missing data were multiply imputed.

RESULTS

We enrolled 630 participants, with 275 in the intervention group and 355 in the control group. A significantly greater percentage of patients in the intervention group met the primary outcome at 12 months (for depressive symptoms: risk difference [RD] 31.03% [62.06% vs. 31.02%, respectively; 95% CI 21.85–40.21]; for HbA_{1c}: RD 19.16% [32.41% vs. 13.25%, respectively; 95% CI 11.35–26.97]). The patients in the intervention group showed significant enhancements in mental quality of life (mean difference [MD] 6.74 [46.57 vs. 39.83, respectively; 95% CI 3.75–9.74]), diabetes self-care activities (MD 0.69 [3.46 vs. 2.78, respectively; 95% CI 0.52–0.86]), medication adherence (MD 0.72 [6.49 vs. 5.78, respectively; 95% CI 0.37–1.07]), and experience of care (MD 0.89 [3.84 vs. 2.95, respectively; 95% CI 0.65–1.12]) at 12 months. Rural participants benefited more from the intervention.

CONCLUSIONS

The implementation strategy can serve as a valuable blueprint for the identification and treatment of patients with physical and mental multimorbidity in primary health care settings.

The co-occurrence of diabetes and depression is a prevalent and noteworthy manifestation of multimorbidity. Diabetes constitutes a rapidly escalating global health crisis

[1]School of Public Health, Peking University, Beijing, China
[2]China Center for Health Development Studies, Peking University, Beijing, China
[3]Department of Research and Teaching, China Aerospace Science & Industry Corporation 731 Hospital, Beijing, China
[4]School of Management, Shandong Second Medical University, Weifang, Shandong, China
[5]Health Commission of Weifang, Weifang, Shandong, China
[6]Peking University Sixth Hospital, Beijing, China
[7]Shanghai Mental Health Center, Shanghai Jiao Tong University School of Medicine, Shanghai, China
[8]Center for Mental Health Management, China Hospital Development Institute, Shanghai Jiao Tong University, Shanghai, China
[9]School of Pharmaceutical Sciences, Beijing, China

Corresponding author: Ping He, phe@pku.edu.cn

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in the new millennium (1). Notably, China boasts the highest prevalence of diagnosed diabetes cases in the world (2). Among individuals with diabetes, depression emerges as the predominant mental health disorder (3). The risk of depression in individuals with type 2 diabetes (T2DM) is 1.5–2.0 times higher than that observed in the general population (4). At least one-third of people with diabetes also have depressive disorders (5). The concurrent prevalence of diabetes and depression ranges between 25% and 45%, with an average of 35.7%, in low- and middle-income countries (LMICs), which is significantly higher than that observed in high-income countries (HICs) (3). In China, approximately 10–50% of patients with diabetes have depression (6); overall point prevalence is 28.9% (7).

Effectively managing the multimorbidity of diabetes and depression poses a formidable challenge for both patients and health care system (8). As a consequence of poor quality of life and diminished life expectancy, these patients experience a significant illness burden. Specifically, depression in people with diabetes exerts adverse influence on glycemic control, increases the risks of microvascular and macrovascular complications (9), diminishes quality of life (10), and even increases mortality (11). In parallel, they also carry a considerable treatment burden. Patients must go to multiple specialist clinics, a process that is not only inconvenient for patients but also inefficient for the health care system itself (12,13). This issue is particularly pronounced in primary health care (PHC) settings in LMICs, where a substantial number of potential patients with mental and physical multimorbidity remain unrecognized and underserved. In addition, this situation arises due to the limited availability of mental health resources and the fragmented nature of the health care delivery system.

The integration of mental and physical health care represents a pivotal approach in the identification and treatment of patients with complex health care challenges. This approach involves the seamless coordination between primary and secondary health care, as well as the integration of health care and social care (14). According to our review, most integrated care models have been developed, implemented, and evaluated in HICs (15). Additionally, previous intervention studies predominantly were conducted in urban settings, raising uncertainties about the generalizability of these findings. In China, since new health care reforms, diabetes management has been well structured within PHC settings. However, with limited mental health resources, a substantial proportion of mental health cases remain undiagnosed and untreated, especially in rural areas, where the challenges of managing physical-mental multimorbidity are particularly acute. In the present study, we implemented and examined the effectiveness of a community-based integrated care model for patients with diabetes and depression (CIC-PDD).

RESEARCH DESIGN AND METHODS

Trial Design

The CIC-PDD study was a pragmatic cluster randomized controlled trial conducted in two counties in China, with randomization at the community health center (CHC) level. The trial protocol and prespecified statistical analysis plan were published previously (16).

Study Population

Patient recruitment occurred in two phases: initial screening and eligibility testing. In the first stage, primary health care providers (PCPs) contacted patients with T2DM and provided a brief overview of the CIC-PDD study. Subsequently, PCPs reviewed existing electronic health records to identify preliminary potential study participants. During the eligibility testing stage, patients who met the initial criteria from the initial screening were invited for additional eligibility assessments and given detailed information about the CIC-PDD intervention.

Eligible participants met the following inclusion criteria: aged $\geq$18 and $\leq$85 years, confirmed diagnosis of T2DM, Patient Health Questionnaire-9 (PHQ-9) score $\geq$10, no serious hearing or vision impairment, able to complete telephone interviews, and willingness to consent to randomization.

If any of the following conditions existed, individuals were excluded from participation: a serious medical condition and/or advanced stage of disease (e.g., heart disease, kidney failure, cancer, major organ failure); diagnosed with bipolar disorder or schizophrenia; currently taking antipsychotic medication or mood stabilizers, or required psychiatric treatment in a medical facility, or had active suicidal thoughts and intent (item 9 of the PHQ-9); pregnant or lactating; lived in a long-term care facility; participated in other clinical trials; had no fixed address or contact details; the PCPs had removed them from the practice diabetes database or, for other reasons, the PCPs considered the patient unsuitable to participate in this study.

All participants, including patients and CHCs, provided written informed consent. The study was approved by the Institutional Review Board at Peking University (no. IRB00001052-21104) and was conducted in accordance with the published protocol.

Randomization

We randomized CHCs in each county on a 1:1 ratio, ensuring an equal number of CHCs (n = 4) in each group. Additionally, the ratio of urban to rural CHCs in both the intervention and control groups was maintained at 1:1. Randomization was performed by a statistician who was not involved in the study's implementation.

Due to the nature of the intervention, blinding of participants and care teams was not feasible. However, all recruited outcome assessors remained blinded to the status of the patient group and worked independently of the intervention team and study team. Additionally, the groups were coded and anonymized, ensuring that researchers were blinded during the entire analysis and writing process.

Intervention Components

The CIC-PDD intervention is grounded in a patient-centered care model, aiming to enhance the continuity, coordination, and efficiency of both mental and physical health care (Supplementary Fig. 1). The key elements of the CIC-PDD model are refined to include a multiprofessional approach, a structured patient treatment plan, scheduled patient follow-up, and enhanced interprofessional communication.

Multi-Professional Approach

The multidisciplinary team comprises three pivotal roles: specialist team, case manager (CM), and health communicator. Each role serves different functions, as described next. For specific details, please refer to the published protocol (16).

Specialist Team. The specialist team consists of a diabetes specialist, psychiatrist, and psychotherapist. Their primary functions include participating in collaborative meetings; offering expert consultation services for patients; delivering training and professional guidance to CMs; assisting CMs in adjusting care plans; and recording regular video sessions to provide ongoing training and patient self-management support.

Case Managers. In the CIC-PDD model, CMs are PCPs. Specifically, in urban settings, CMs are typically general practitioners, whereas in rural areas, village doctors take on this role. Their key responsibilities include delivering proactive follow-up services over 18 sessions for patients; attending team meetings to report on key patients' conditions; and making necessary adjustments to the management plan as needed. In addition, CMs act as intermediaries between patients and the specialist team.

Health Communicators. Students from medical universities are recruited as health communicators. Their main responsibilities include organizing and documenting team meetings; conducting online health status assessments (e-visits); verifying the quality of follow-up visits; and supporting patient self-management.

A Structured Patient Treatment Plan

Each patient receives a tailored treatment plan based on the CIC-PDD manuals. The CIC-PDD model uses measurement and monitoring techniques, incorporating behavioral activation strategies, and technology-based tools (e.g., WeChat official account).

Scheduled Patient Follow-up

In this study patients were proactively followed up by CMs over a maximum of 18 sessions over 1 year, encompassing both high-intensity and low-intensity phases. These sessions were conducted either in person or via telephone.

Enhanced Interprofessional Communication

To improve interprofessional communication and patient management, collaborative meetings have been instituted. The health communicators are responsible for organizing these meetings to assist CMs and the specialist team in reviewing patient progress and developing effective management strategies.

Supplementary Fig. 1 shows the potential components of CIC-PDD model. In the control group, PCPs were to be informed about patients' depressive symptoms. Notably, health management of patients with T2DM is one of the services provided by the Basic Public Health Service Package. Therefore, patients in the control group received enhanced usual care (EUC).

Data Collection and Follow-up

Patients in both groups attended study assessments at baseline (prior to randomization) and at 6 and 12 months. Data collection through interviews was conducted by trained outcome assessors who were blinded to group assignments.

Throughout the study, patients were queried about the occurrence of serious adverse events. Given the patient population, the occurrence of deaths was expected. CMs reported full details of each adverse event, including any potential associations with the intervention. These details were then discussed with the independent data monitoring committee.

Outcomes

The primary outcome was the between-group difference in the unadjusted percentage of patients achieving at least a 50% improvement in depression symptoms, as measured by the Symptom Checklist-20 (SCL-20) (17), and at least a 0.5 percentage point reduction in HbA_{1c} at 6 and 12 months.

Several secondary outcomes were defined for process analysis and mechanism investigation. We assessed change in quality of life using the 12-Item Short Form Health Survey (18). Additionally, we assessed changes in self-management behaviors and perceptions, including diabetes self-care activities (Summary of Diabetes Self-Care Activities Questionnaire) (19) and medication adherence (Morisky Medication Adherence Scale) (20); and burden of treatment (Multimorbidity Treatment Burden Questionnaire) (21). Furthermore, data on the care process experience were collected using the Patient Assessment of Chronic Illness Care (PACIC) (22).

Statistical Analysis

The study's statistical power was based on detecting between-arm differences in achieving the primary outcome. We adjusted for the potential clustering effect by using an intraclass correlation coefficient of 0.03. This adjustment was based on previous literature (23) and ensures that the power calculation is appropriate for the study design. Specifically, with a sample size of 480 patients (n = 240 per group) across eight CHCs, we achieved greater than 80% power to detect a 20% absolute mean difference (MD) between groups for the primary outcome (α = 0.05). To further ensure robustness, we accounted for a 10–15% potential loss to follow-up by increasing the sample size to 280 per group. To tour knowledge, this study has the largest sample size among similar studies.

We used multiple imputation techniques to handle missing data. This process yielded 30 complete data sets for analysis, taking into account the randomization group and covariates. Given the missing data comprise individuals who died or who withdrew from the study, our primary analysis was conducted excluding these participants. As a part of sensitivity analysis, we reevaluated our findings using the data after multiple imputations.

We undertook an intention-to-treat analysis for all outcomes, analyzing data according to patients' randomization group. The risk differences (RDs) in achieving the primary outcome between the intervention and usual care groups at 6 and 12 months were calculated. Between-group differences in means of secondary outcomes were estimated using linear regression models. The aforementioned analysis did not adjust for baseline characteristics but did account for clustering by using cluster SEs at the CHC level. In addition, we conducted a sensitivity analysis by controlling for baseline patient characteristics, which included sex, age, marital status, residency, educational attainment, household income, tobacco use, and alcohol use. Prespecified subgroup analyses were conducted on the basis of the baseline characteristics to investigate potential heterogeneity in intervention effects. For each subgroup, the primary analysis was repeated, incorporating the subgroup variable and its interaction with the treatment to assess the significance of the subgroup effects.

Analyses were conducted using Stata 17. Estimates are presented with 95% CIs using two-sided statistical tests, with a significance threshold of $P < 0.05$. The conduct of the trial was monitored by independent trial steering and data

monitoring committees. This trial was registered with the Chinese Clinical Trial Registry (registration no. ChiCTR2200065608).

RESULTS

We recruited eight CHCs, which collectively served 4,735 patients with diabetes. A total of 3,759 patients were invited to participate in the baseline assessment. Among these patients, 275 individuals eventually were assigned to the CIC-PDD group and 355 were assigned to the control group. Recruitment commenced on 1 December 2022 and was completed on 20 January 2023. Differences by study arm are illustrated in Supplementary Fig. 2.

Table 1 lists demographic characteristics and clinical variables of participants at baseline. Of 630 participants, most were older (mean age [SD], 67.58 [7.16] years), female (*n* = 441; 70.00%), married (*n* = 525; 83.33%), lived in a rural area (*n* = 451; 71.59%), and had a middle school education or less (*n* = 406; 64.44%). Most participants did not smoke (*n* = 509; 80.79%) or drink alcohol (*n* = 488; 77.46%). The patients' SCL-20 score and HbA_{1c} level were 1.37 (SD 0.67) and 8.11 (SD 1.39), respectively. Patients in the two study arms were similar in most respects.

Outcome data were available for 601 (95.40%) and 585 (92.86%) participants at the 6- and 12-month follow-up visits. In terms of primary outcomes, statistically significant differences were observed between the CIC-PDD and EUC groups. Intervention participants were more likely to achieve a 50% reduction in depressive symptoms (RD 29.92% [49.81% vs. 19.88%, respectively]; 95% CI 20.84–39.01)

Table 1—Baseline characteristics of the study participants

Characteristic	Overall	EUC group	Integrated care group	*P* value
n	630	355	275	
Sociodemographic characteristics *n*(%)				
Sex				0.011
Male	189 (30.00)	92 (25.92)	97 (35.27)	
Female	441 (70.00)	263 (74.08)	178 (64.73)	
Age, mean (SD), years	67.58 (7.16)	67.91 (7.01)	67.15 (7.35)	0.19
Marital status				0.693
Married	525 (83.33)	294 (82.82)	231 (84.00)	
Not married	105 (16.67)	61 (17.18)	44 (16.00)	
Residency				<0.001
Urban	179 (28.41)	78 (21.97)	101 (36.73)	
Rural	451 (71.59)	277 (78.03)	174 (63.27)	
Educational attainment				0.709
Middle school or less	406 (64.44)	231 (65.07)	175 (63.64)	
High school or more	224 (35.56)	124 (34.93)	100 (36.36)	
Household income (RMB)				0.001
<26,000	349 (55.40)	218 (61.41)	131 (47.64)	
≥26,000	281 (44.60)	137 (38.59)	144 (52.36)	
Tobacco use				0.048
Currently	54 (8.57)	28 (7.89)	26 (9.45)	
Ever	67 (10.63)	29 (8.17)	38 (13.82)	
Quit	509 (80.79)	298 (83.94)	211 (76.73)	
Alcohol use				0.008
Currently	80 (12.70)	40 (11.27)	40 (14.55)	
Ever	62 (9.84)	25 (7.04)	37 (13.45)	
Quit	488 (77.46)	290 (81.69)	198 (72.00)	
Clinical characteristics				
Diabetes and depression indices				
SCL-20 score, mean (SD)	1.37 (0.67)	1.38 (0.69)	1.37 (0.64)	0.849
HbA_{1c} (%), mean (SD)	8.11 (1.39)	8.09 (1.19)	8.14 (1.61)	0.694
Quality of life				
PCS-12 score, mean (SD)	36.62 (9.22)	37.05 (9.38)	36.05 (9.00)	0.176
MCS-12 score, mean (SD)	36.85 (18.54)	36.15 (20.6)	37.77 (15.49)	0.276
Behaviors and perceptions				
SDSCA score, mean (SD)	2.59 (0.77)	2.57 (0.79)	2.61 (0.75)	0.428
Morisky-8 score, mean (SD)	5.55 (2.21)	5.45 (2.32)	5.7 (2.06)	0.184
MTBQ score, mean (SD)	7.1 (13.67)	6.59 (12.62)	7.76 (14.92)	0.287
Experience of care				
PACIC-20 score, mean (SD)	2.96 (1.11)	2.94 (1.08)	2.98 (1.15)	0.725

MCS-12, Mental Component Summary-12; Morisky-8, Morisky Medication Adherence Scale 8; MTBQ, Multimorbidity Treatment Burden Questionnaire; PCS-12, Physical Component Summary-12; SDSCA, Summary of Diabetes Self-Care Activities Questionnaire.

compared with the EUC group. For HbA_{1c} at 6 months, the RD was 11.50% (19.69% vs. 8.19%, respectively; 95% CI 5.17–17.84). At 12 months, the CIC-PDD group had an RD of 31.03% (62.06% vs. 31.02%, respectively; 95% CI 21.85–40.21) for depressive symptoms and 19.16% (32.41% vs. 13.25%, respectively; 95% CI 11.35–26.97) for HbA_{1c} compared with the EUC group (Fig. 1 and Table 2). Sensitivity analyses showed that these findings were robust in adjusted models (Supplementary Tables 1 and 2).

Results for measures of secondary outcomes at 6 months are presented in Table 2. There was no evidence of a difference between the intervention and EUC groups with respect to measures of physical health-related quality of life. Compared with the EUC group, the intervention group demonstrated higher mental health-related quality of life, with an MD of 5.67 (42.99 vs. 37.32, respectively; 95% CI 2.73–8.60) at 6 months and 6.74 (46.57 vs. 39.83, respectively; 95% CI 3.75–9.74) at 12 months.

Moreover, regarding changes in behaviors and perceptions, patients in the intervention group made significant improvements in diabetes self-care activities, with an MD of 0.68 (3.35 vs. 2.67, respectively; 95% CI 0.54–0.83) at 6 months and 0.69 (3.46 vs. 2.78, respectively; 95% CI 0.52–0.86) at 12 months. Additionally, medication adherence improved, with an MD of 0.63 (6.33 vs. 5.70, respectively; 95% CI 0.28–0.97) at 6 months and 0.72 (6.49 vs. 5.78, respectively; 95% CI 0.37–1.07) at 12 months. No cases of patients taking antidepressants were found.

The assessment of patient-centered care, measured by the PACIC scale, also revealed benefits from the intervention, with an MD of 0.52 (3.49 vs. 2.97, respectively; 95% CI = 0.35–0.69) at 6 months and 0.89 (3.84 vs. 2.95, respectively; 95% CI 0.65–1.12) at 12 months.

Notably, the rural participants derived more benefits compared with the urban in primary outcomes (for depressive symptoms, $P = 0.047$; for HbA_{1c}, $P = 0.032$) (Fig. 2). Additionally, medication adherence ($P = 0.016$) and diabetes self-care activities ($P < 0.001$) also showed a more pronounced effect in the rural population (Supplementary Figs. 3 and 4).

During the trial, a total of 12 (1.90%) of the 630 patients died, and 33 (5.24%) withdrew from the study. There was no evidence of a difference in the number of patients lost to follow-up between the intervention and control group ($\chi^2 = 1.58$; $P = 0.208$) (Supplementary Table 3). None of the deaths were possibly associated with the CIC-PDD intervention. In addition, the sensitivity analysis was conducted to mitigate the bias from missing data, and the results remained consistent (Supplementary Tables 4 and 5).

CONCLUSIONS

In this cluster randomized control trial involving patients with diabetes and depression, a multicomponent integrated care intervention (CIC-PDD) achieved clinically meaningful improvements in depression and HbA_{1c}, especially among rural participants. Compared with EUC, there were enhancements in diabetes self-management activities and medication adherence. Furthermore, the intervention led to noteworthy enhancements in the patient-centered care experience.

The trial provides new insights into the effects of an integrated care model on clinical parameters among patients with diabetes and depression. This study has identified that the CIC-PDD intervention was effective in ameliorating depressive symptoms in patients with both depression and diabetes, aligning with our prior systematic review (15). Additionally, we also found that intervention resulted in significant enhancements in emotional functional outcomes, consistent with the Ell et al. study (24). In contrast, Johnson et al. (25) did not observe a positive effect, likely due to a smaller sample size. Regarding physical health, the present study revealed that the intervention yielded improvements in patients' HbA_{1c} values and did not affect physical health-related quality of life. Other related but substantially more intensive interventions also did not demonstrate

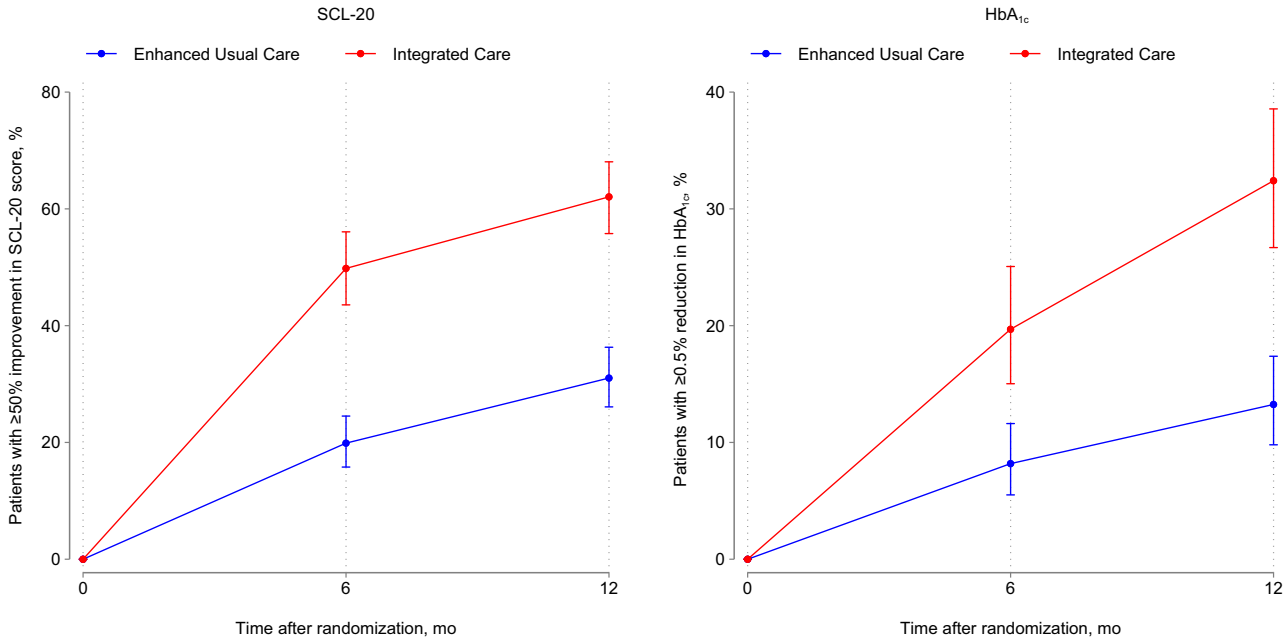

Figure 1—Effects of CIC-PDD Intervention on Primary Outcomes (12 months). The dots represent the estimated values (red: intervention group; blue: control group), and the bars represent 95% confidence intervals.

Table 2—Effectiveness of the CIC-PDD intervention on the primary and secondary outcomes

	6-Month follow-up				12-Month follow-up			
Outcome	EUC group	Integrated care group	Unadjusted difference	*P* value*	EUC group	Integrated care group	Unadjusted difference	*P* value*
n	342	259			332	253		
Primary outcome								
RD								
≥50% improvement in SCL-20 score	68 (19.88)	129 (49.81)	29.92 (20.84 to 39.01)	**<0.001**	103 (31.02)	157 (62.06)	31.03 (21.85 to 40.21)	**<0.001**
≥0.5-percentage point reduction in HbA_{1c}	28 (8.19)	51 (19.69)	11.5 (5.17 to 17.84)	**<0.001**	44 (13.25)	82 (32.41)	19.16 (11.35 to 26.97)	**<0.001**
Secondary outcomes								
MD								
SCL-20 score, mean (SD)	1.26 (0.73)	0.76 (0.58)	−0.51 (−0.61 to −0.40)	**<0.001**	1.08 (0.69)	0.64 (0.57)	−0.44 (−0.54 to −0.33)	**<0.001**
HbA_{1c}, mean (SD)	8.08 (1.06)	7.99 (1.43)	−0.08 (−0.28 to 0.12)	0.408	8.03 (1.07)	7.81 (1.37)	−0.21 (−0.41 to −0.01)	**0.036**
Quality of life								
PCS-12 score, mean (SD)	37.68 (9.09)	38.66 (11.72)	0.98 (−0.68 to 2.64)	0.248	38.63 (10.94)	40.06 (11.92)	1.42 (−0.44 to 3.28)	0.134
MCS-12 score, mean (SD)	37.32 (19.59)	42.99 (16.16)	5.67 (2.73 to 8.6)	**<0.001**	39.83 (19.8)	46.57 (16.18)	6.74 (3.75 to 9.74)	**<0.001**
Change in behaviors and perceptions								
SDSCA score, mean (SD)	2.67 (0.95)	3.35 (0.86)	0.68 (0.54 to 0.83)	**<0.001**	2.78 (1.02)	3.46 (1.05)	0.69 (0.52 to 0.86)	**<0.001**
Morisky-8 score, mean (SD)	5.70 (2.16)	6.33 (1.79)	0.63 (0.28 to 0.97)	**<0.001**	5.78 (2.4)	6.49 (1.46)	0.72 (0.37 to 1.07)	**<0.001**
MTBQ score, mean (SD)	6.33 (11.88)	6.09 (14.00)	−0.24 (−2.31 to 1.83)	0.822	6.15 (10.61)	5.71 (9.69)	−0.44 (−2.12 to 1.23)	0.603
Experience of care								
PACIC-20 score, mean (SD)	2.97 (1.08)	3.49 (0.89)	0.52 (0.35 to 0.69)	**<0.001**	2.95 (1.18)	3.84 (1.01)	0.89 (0.65 to 1.12)	**<0.001**

Data are reported as mean (SD) or *n* (%), unless otherwise indicated; treatment effects are presented as unadjusted results. **P* values represent statistical significance of overall between-group RD or MD calculated by cluster SE. Values in bold are statistically significant. MCS-12, Mental Component Summary-12; Morisky-8, Morisky Medication Adherence Scale 8; MTBQ, Multimorbidity Treatment Burden Questionnaire; PCS-12, Physical Component Summary-12; SDSCA, Summary of Diabetes Self-Care Activities Questionnaire.

evidence of improved quality of life (24). The results regarding HbA_{1c} were consistent with those reported in some previous reviews (26), but differed from others (15,27). Moreover, the findings of this study align with those of the Integrating Depression and Diabetes Treatment (INDEPENDENT) study conducted in India (28). In contrast, we observed an expansion in effects from 6 to 12 months, which may be attributed to differences in the intervention plan. Previous studies implemented follow-up intervals ranging from weekly to monthly. In comparison, the CIC-PDD model, which consists of two phases with a relatively moderate follow-up frequency, appears to show effects attributable directly to the care plan itself. To delve deeper into its mechanism, the study uncovered participants in the intervention group made significantly greater improvements in self-health management, encompassing enhancements in diabetes self-care behaviors and medication adherence.

Despite the absence of significant changes in treatment burden, patients reported notable improvements in care experience. Although few studies have focused on the measurement of patients' self-perceptions, these perceptions are crucial in the patient-centered care model (15). Additionally, managing multimorbidity imposes a substantial burden on patients, in addition to the burden of illness (3,28). In China, limited resources have led to inadequate attention to mental health concerns, particularly in PHC settings, with only 0.5% of patients with depressive disorders receiving adequate treatment (29). Consequently, patients may not yet be fully aware of the treatment burden associated with depression, rendering current measurement tools insufficiently sensitive for these patients. When comparing our results with other multimorbidity patterns (30), it is evident that participants in our study experienced a relatively lower treatment burden. The changes implemented through the CIC-PDD intervention were significant enough to report improvements in the patient-centered care experience. The fragmentation of mental and physical health care often results in poorly coordinated health care (28). Enhancing the patient experience aligns with one of the three aims of health care (31). Therefore, delivering integrated care that is demonstrably more patient-centered can be seen as a sufficient justification for its implementation.

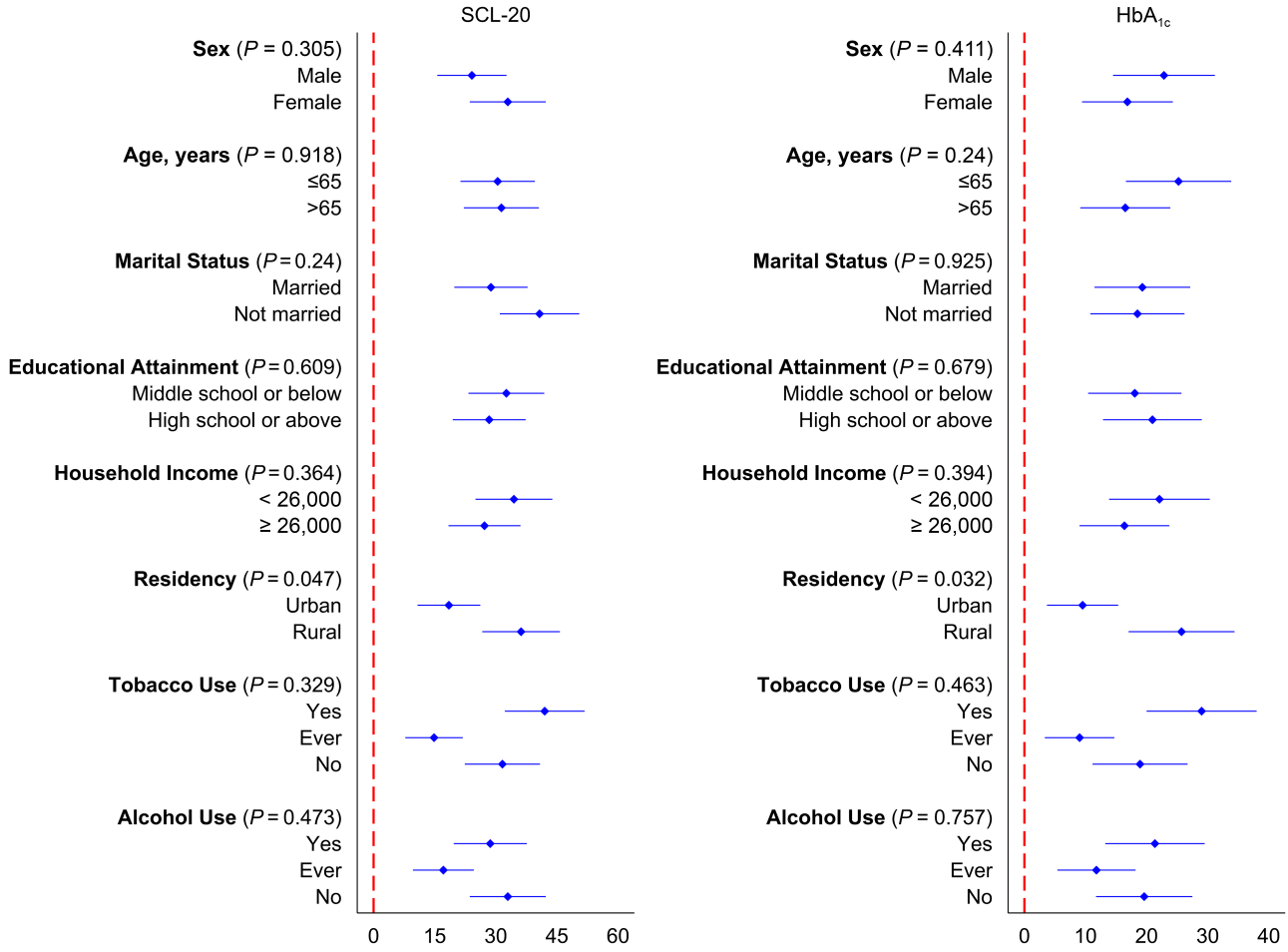

Figure 2—Subgroup Analysis of Primary Outcomes (12 months). The dots represent the estimated RDs between the intervention and control groups across various categories, and the bars represent 95% CIs.

The CIC-PDD intervention helps address the urban-rural inequality in multimorbidity, with more pronounced benefits observed in patients residing in rural areas. For the majority of subgroups, this study did not reveal significant heterogeneity in treatment effects. The possible explanation is that the sample size hindered meaningful subgroup analysis and conclusions. Nevertheless, patients in rural areas experienced more significant improvements in primary outcomes in this study. On one hand, this may be attributed to this subgroup's lower socioeconomic status and lower awareness of self-health management compared with their urban counterparts. Consequently, patients in rural areas seemed to be more responsive to the intervention. This is affirmed by a higher degree of medication adherence and more significant improvements in diabetes self-management activities in rural areas (Supplementary Figs. 2 and 3). Additionally, in rural areas, the village physician has a closer social bond beyond their trustworthy doctor-patient relationship, compared with patients in urban settings (32).

This study provides valuable insights into the management of physical and mental multimorbidity within PHC settings. In China, there are approximately 20,000 psychiatrists, of whom only about 4,000 are fully qualified (33). Moreover, it has been observed that high-quality mental health services are predominantly centralized within major psychiatric specialty hospitals in urban areas (29). The CIC-PDD model achieves a redeployment of the scarce resources. This study furnishes new evidence that the effective identification and treatment of patients with diabetes and depression can be accomplished even in diverse, low-resource, and fragmented health care settings.

Our findings provide crucial and actionable insights for the advancement of integrated care models and theories. The CIC-PDD model achieves the triple integration of physical and mental health, primary (CM) and secondary care (specialist team), and health and social care (health coordinators). In HICs, the role of the CM is typically performed by a nurse (15,34). However, in rural areas of China, there is a shortage of nurses, and in urban CHCs, nurses mainly focus on medical services. In the CIC-PDD model, we designated PCPs as CMs and introduced health communicators to bridge the gap between CMs and specialist teams. Establishing this PCP-led integrated model underscores the need for contextual adaptation when implementing it in diverse PHC settings. Effective adaptation will require aligning the model with the primary roles of local PCPs and the structure of health care human resources.

Future efforts should focus on refining and adapting the CIC-PDD model. This could involve initiatives such as integrating the model with electronic

health record systems and developing digital platforms for multimorbidity management. In addition, longer-term implementation studies are needed to fully understand the CIC-PDD model, including its cost-effectiveness and optimal methods to integrate it into routine practice, as well as its generalizability and sustainability. Considering that the implementation of CIC-PDD involves changes in health care service delivery mode and health resources, it is essential to analyze the components and evolving trends of facilitators and barriers. This would contribute to the generalizability and the feasibility of translating the model into practice.

Strengths

This trial has several notable strengths. First, it is a well-powered trial of an integrated care intervention aimed at enhancing the treatment of patients with comorbid depression and diabetes. It is also, to our knowledge, the first intervention study tailored for patients with multimorbidity, and stands as the pioneering implementation study providing microlevel evidence for an integrated health care system in China. Second, the trial is highly pragmatic, effectively demonstrating the practicability, acceptability, and effectiveness of the CIC-PDD model. Finally, unlike previous studies conducted exclusively in urban clinic settings, this study encompassed CHCs from both rural and urban areas, enabling a comprehensive representation of PHC and community settings. Importantly, this study not only broadens the scope of the study but also provides evidence that the CIC-PDD model mitigates health inequality related to mental and physical multimorbidity across urban and rural divides.

Limitations

The CIC-PDD study, along with this analysis, has some limitations. First, the results presented are based on two follow-up assessments at 6 and 12 months, and the maintenance effects remain uncertain. Although the data presented show significantly efficacy of CIC-PDD intervention, we acknowledge that observing the sustained effects is necessary to enhance its potential for practical implementation. Second is that self-reported outcomes may introduce assessment bias. To address this, all outcome assessors received training on the survey tools and underwent simulated assessments, and all outcome data were collected through in-person interviews. We implemented a strict protocol during the data collection process, ensuring that interviews occurred within a dedicated, isolated space. Additionally, stringent measures were enforced to ensure that no unrelated individuals were present on-site. Last, there was a slight imbalance in cluster size and individual-level characteristics at baseline, a common issue in cluster designs. We took meticulous steps to mitigate potential selection bias, including concealing randomization allocation until the completion of recruitment and baseline data collection. Moreover, we made adjustments for predefined covariates.

Conclusions

We have demonstrated that patients with comorbid depression and diabetes can attain significant benefits from CIC-PDD interventions, with particularly notable advantages in rural areas under the PCP-led care model in China. It is of utmost importance for the health and well-being of individuals with mental and physical multimorbidity that future research focuses on effectively implementing integrated care models into routine PHC settings in LMICs. In this study, we provide a blueprint, a veritable template, for such efforts.

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References

1. Zimmet PZ, Magliano DJ, Herman WH, Shaw JE. Diabetes: a 21st century challenge. Lancet Diabetes Endocrinol 2014;2:56–64
2. Yang W, Lu J, Weng J, et al.; China National Diabetes and Metabolic Disorders Study Group. Prevalence of diabetes among men and women in China. N Engl J Med 2010;362:1090–1101
3. Anderson RJ, Freedland KE, Clouse RE, Lustman PJ. The prevalence of comorbid depression in adults with diabetes: a meta-analysis. Diabetes Care 2001;24:1069–1078
4. van Sloten TT, Sedaghat S, Carnethon MR, Launer LJ, Stehouwer CDA. Cerebral microvascular complications of type 2 diabetes: stroke, cognitive dysfunction, and depression. The Lancet Diabetes & Endocrinology 2020;8:325–336
5. Lloyd CE, Pambianco G, Orchard TJ. Does diabetes-related distress explain the presence of depressive symptoms and/or poor self-care in individuals with type 1 diabetes? Diabet Med 2010;27:234–237
6. Liu H, Xu X, Hall JJ, Wu X, Zhang M. Differences in depression between unknown diabetes and known diabetes: results from China Health and Retirement Longitudinal Study. Int Psychogeriatr 2016;28:1191–1199
7. Liu X, Dong C, Jiang H, et al. Prevalence and risk factors of depression in Chinese patients with type 2 diabetes mellitus: a protocol of systematic review and meta-analysis. Syst Rev 2021;10:302
8. Petrak F, Baumeister H, Skinner TC, Brown A, Holt RIG. Depression and diabetes: treatment and health-care delivery. Lancet Diabetes Endocrinol 2015;3:472–485
9. de Groot M, Anderson R, Freedland KE, Clouse RE, Lustman PJ. Association of depression and diabetes complications: a meta-analysis. Psychosom Med 2001;63:619–630
10. Moussavi S, Chatterji S, Verdes E, Tandon A, Patel V, Ustun B. Depression, chronic diseases, and decrements in health: results from the World Health Surveys. Lancet 2007;370:851–858
11. Baumeister H, Hutter N, Bengel J, Härter M. Quality of life in medically ill persons with comorbid mental disorders: a systematic review and meta-analysis. Psychother Psychosom 2011;80:275–286
12. Smith SM, Soubhi H, Fortin M, Hudon C, O'Dowd T. Managing patients with multimorbidity: systematic review of interventions in primary care and community settings. BMJ 2012;345:e5205
13. Petersen I, Kemp CG, Rao D, et al. Implementation and scale-up of integrated depression care in South Africa: an observational implementation research protocol. Psychiatr Serv 2021;72:1065–1075
14. Pearson-Stuttard J, Ezzati M, Gregg EW. Multimorbidity-a defining challenge for health systems. Lancet Public Health 2019;4:e599–e600

15. Wang Y, Hu M, Zhu D, Ding R, He P. Effectiveness of collaborative care for depression and HbA_{1c} in patients with depression and diabetes: a systematic review and meta-analysis. Int J Integr Care 2022;22:12
16. Wang Y, Guo D, Wang M, et al. Community-based integrated care for patients with diabetes and depression (CIC-PDD): study protocol for a cluster randomized controlled trial. Trials 2023; 24:550
17. Derogatis LR, Lipman RS, Rickels K, Uhlenhuth EH, Covi L. The Hopkins Symptom Checklist (HSCL): a self-report symptom inventory. Behav Sci 1974; 19:1–15
18. Ware J, Kosinski M, Keller SD. A 12-item short-form health survey: construction of scales and preliminary tests of reliability and validity. Med Care 1996;34:220–233
19. Toobert DJ, Glasgow RE. Assessing diabetes self-management: the summary of diabetes self-care activities questionnaire. In Handbook of Psychology and Diabetes: A Guide to Psychological Measurement in Diabetes Research and Practice, C. Bradley, Ed. Reading, U.K., Harwood Academic Publishers/Gordon & Breach, 1994, pp. 351–375
20. Morisky DE, Green LW, Levine DM. Concurrent and predictive validity of a self-reported measure of medication adherence. Med Care 1986;24:67–74
21. Duncan P, Murphy M, Man M-S, Chaplin K, Gaunt D, Salisbury C. Development and validation of the Multimorbidity Treatment Burden Questionnaire (MTBQ). BMJ Open 2018;8:e019413
22. Glasgow RE, Wagner EH, Schaefer J, Mahoney LD, Reid RJ, Greene SM. Development and validation of the Patient Assessment of Chronic Illness Care (PACIC). Med Care 2005;43: 436–444
23. Cummings DM, Lutes LD, Littlewood K, et al. Randomized trial of a tailored cognitive behavioral intervention in type 2 diabetes with comorbid depressive and/or regimen-related distress symptoms: 12-month outcomes from COMRADE. Diabetes Care 2019;42:841–848
24. Ell K, Katon W, Xie B, et al. Collaborative care management of major depression among low-income, predominantly Hispanic subjects with diabetes: a randomized controlled trial. Diabetes Care 2010;33:706–713
25. Johnson JA, Al Sayah F, Wozniak L, et al. Collaborative care versus screening and follow-up for patients with diabetes and depressive symptoms: results of a primary care–based comparative effectiveness trial. Diabetes Care 2014;37:3220–3226
26. Atlantis E, Fahey P, Foster J. Collaborative care for comorbid depression and diabetes: a systematic review and meta-analysis. BMJ Open 2014;4:e004706
27. Huang Y, Wei X, Wu T, Chen R, Guo A. Collaborative care for patients with depression and diabetes mellitus: a systematic review and meta-analysis. BMC Psychiatry 2013;13:260
28. Ali MK, Chwastiak L, Poongothai S, et al. Effect of a collaborative care model on depressive symptoms and glycated hemoglobin, blood pressure, and serum cholesterol among patients with depression and diabetes in India: the INDEPENDENT randomized clinical trial. JAMA 2020;324(7):651–662
29. Lu J, Xu X, Huang Y, et al. Prevalence of depressive disorders and treatment in China: a cross-sectional epidemiological study. Lancet Psychiatry 2021;8:981–990
30. Salisbury C, Man M-S, Bower P, et al. Management of multimorbidity using a patient-centred care model: a pragmatic cluster-randomised trial of the 3D approach. Lancet 2018;392:41–50
31. Berwick DM, Nolan TW, Whittington J. The triple aim: care, health, and cost. Health Aff (Millwood) 2008;27:759–769
32. He J, Ouyang N, Guo X, et al.; CRHCP Study Group. Effectiveness of a non-physician community health-care provider-led intensive blood pressure intervention versus usual care on cardiovascular disease (CRHCP): an open-label, blinded-endpoint, cluster-randomised trial. Lancet 2023;401:928–938
33. Xiang Y-T, Yu X, Sartorius N, Ungvari GS, Chiu HFK. Mental health in China: challenges and progress. Lancet 2012;380:1715–1716
34. Morgan M, Dunbar J, Reddy P, Coates M, Leahy R. The TrueBlue study: is practice nurse-led collaborative care effective in the management of depression for patients with heart disease or diabetes? BMC Fam Pract 2009;10:46