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Research paper

Effectiveness of an integrated prevention programme ("JoyAge") for depressive symptoms, anxiety, and loneliness in older adults in Hong Kong: A pragmatic quasi-experimental trial

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ABSTRACT

Background: With population ageing and insufficient mental health workforce, there are huge treatment gaps for late-life depression. Real-world evidence of scalable preventive services is scarce. This study examines the effectiveness of an integrated selective and indicated prevention programme for late-life depression in a large group of older adults in Hong Kong.

Methods: This was a pragmatic quasi-experimental trial of a new service ("JoyAge") for older people with risk factors for late-life depression or subsyndromal depressive symptoms. Participants were recruited and allocated, based on their district of residence, to receive JoyAge ($N = 2975$) or usual care ($N = 441$). The primary outcome was depressive symptoms (PHQ-9) at 12-month follow-up; secondary outcomes were anxiety symptoms (GAD-7) and loneliness (UCLA-3). Analyses were conducted in an intention-to-treat framework using mixed modelling, with subgroup analyses based on baseline depressive symptoms, and sensitivity analyses in a 1:1 ($N = 422$ each group) propensity score-matched sample.

Results: The JoyAge participants had a greater reduction in depressive symptoms over the 12-month period compared to those assigned to usual care (adjusted mean difference [AMD] = 1.65, 95% CI = 1.24–2.07, $p < .001$), similarly in anxiety symptoms (AMD = 1.47, 95% CI = 1.01–1.93, $p < .001$), and loneliness (AMD = 1.29, 95% CI = 0.98–1.60, $p < .001$). Results were similar in propensity-score matched analyses. Subgroup analysis showed that JoyAge was particularly effective among people with moderate to moderately severe symptoms and those with risk factors only.

Conclusions: Integrated late-life depression prevention can be effectively implemented at scale in rapidly ageing settings with a limited specialist mental health workforce. Economic analyses are needed to support further implementation.

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1. Background

With the population ageing, there is an enormous and growing need for care and treatment of common mental disorders in older populations, but there is a widespread shortage of workforce (Reynolds et al., 2022). Depression is prevalent in older people, frequently with comorbid physical conditions and social risk factors associated with age (Herrman et al., 2022; Reynolds et al., 2022). Currently, one billion people worldwide are older than 60 years (World Health Organisation, 2024). Projected population ageing is particularly marked in Asia; Hong Kong will become the oldest society by 2050, with older people making up 40.6% of the population (United Nations Department of Economic and Social Affairs, 2023). Despite a developed economy, Hong Kong is significantly underpowered in mental health workforce. For example, there were only 5.55 psychiatrists per 100,000 population in 2022, compared with 16.8 in Organisation for Economic Co-operation and Development (OECD) countries (World Health Organisation, 2019). The case for the prevention of late-life depression is well established (Reynolds et al., 2022). The rationales include incomplete treatment response once a major depressive disorder has developed (Schoevers et al., 2006), stigma and other barriers in accessing treatment (Cuijpers et al., 2019; Horackova et al., 2019), and significant health consequences associated with late-life depression, such as all-cause mortality and dementia (Dafsari and Jessen, 2020; Wei et al., 2019). Selective prevention targeting older people with risk factors and indicated prevention targeting those with subsyndromal symptoms may be effective (van't Veer-Tazelaar et al., 2011). Growing attention is being paid to risk factors such as loneliness, social network integration and community activities (Lee et al., 2021; Santini et al., 2020), stepped care (Rivero-Santana et al., 2021), and task-sharing approaches (Schwei et al., 2021), such as lay counsellors in India (Dias et al., 2019) and community health workers in Brazil (Scazufca et al., 2022). A recent review on mental health care for older people highlighted pragmatic programmes, including collaborative and stepped care and task-sharing, as some of the new directions in clinical practice and research (Reynolds et al., 2022).

Integrated preventive programmes can be developed incorporating these components, but real-world evidence on their effectiveness is scarce. Hong Kong has recently developed and implemented an integrated prevention programme (Jockey Club Holistic Support Project for Elderly Mental Wellness, JC "JoyAge") (JC JoyAge, 2017). The programme involves stepped-care for selective and indicated prevention, collaborative care between community mental health and aged care services to deliver evidence-based psychotherapies, and peer support involving 'young-old' volunteers (aged ≥50 years) with stipends, based on equitable productive ageing principles (Liu et al., 2022). JoyAge was first launched in four of the 18 districts in Hong Kong, providing an opportunity for a pragmatic trial (Ford and Norrie, 2016), by comparing the programme with care-as-usual (CAU) in service units where JoyAge had not yet been implemented. This study aimed to examine the effectiveness of the JoyAge programme in reducing depressive symptoms (primary outcome), anxiety, and loneliness (secondary outcomes) among older adults with risk factors or subsyndromal symptoms, compared to usual care. We hypothesised that participants receiving the JoyAge intervention would show a significantly greater reduction in these symptoms over a 12-month period.

2. Methods

2.1. Study design

This pragmatic quasi-experimental trial was conducted in a community setting in Hong Kong from October 2017 to December 2019, in partnership with NGOs providing aged and mental health care. Group allocation was based on the district of residence. Residents in JoyAge districts (4/18 districts) were assigned to the intervention group, and residents in other districts were assigned to the control group. Out of pragmatic considerations, the study was single-blinded, with an intervention vs control allocation ratio of 4:1 (which allowed for propensity score matching); see study protocol for detailed rationale of the unequal allocation (Liu et al., 2022).

The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2013. All procedures involving human subjects/patients were approved by the Institutional Review Board of The University of Hong Kong/Hospital Authority Hong Kong West Cluster (HKU/HA HKW) (Reference No.: UW 20–246) and the Human Research Ethics Committee of HKU (Reference No.: EA2004028).

2.2. Participants

Participants were recruited through community outreach and open referral via partnering NGOs. We reported the sample size calculation elsewhere (Liu et al., 2022). Briefly, assuming effect sizes of 0.2–0.3 for different levels of prevention, with $\alpha = 0.05$, power of 0.80, and assuming a dropout rate of around 30%, a total sample of 2542 participants is needed (508 control, 2034 intervention). Inclusion criteria were: 1) age 60 years or above; 2) at risk of depression, operationalised as scoring below 5 on the Patient Health Questionnaire (PHQ-9) and having risk factors (predefined as loneliness, social isolation, chronic pain, history of depression/anxiety, recent bereavement, >4 chronic diseases, <30 mins of daily meaningful activities); or having mild to moderately severe depressive symptoms, operationalised as scoring between 5 and 19 on PHQ-9; and 3) able to give informed consent to participate. Exclusion criteria were: 1) known history of autism spectrum disorder, intellectual disability, schizophrenia-spectrum disorder, bipolar disorder, Parkinson's disease, or dementia (clinically diagnosed or based on research criteria using the Hong Kong Montreal Cognitive Assessment 5-Minute Protocol) (Wong et al., 2015); 2) imminent suicidal risk (temporary exclusion criteria); and 3) difficulty in communication. Individuals who were excluded due to severe depressive symptoms (PHQ-9 ≥ 20) or imminent suicidal risk were provided with immediate referrals to specialist mental health services by the trained social workers conducting the assessments.

2.3. Procedure

All participants provided written informed consent before enrolling. Clinical social workers conducted clinical intake and assessment interviews with the participants. The assessment involved tools that evaluate depression, suicidal risks, and other outcomes (see Outcome Measures). Participants were then assigned to the JoyAge or control groups based on district of residence as previously mentioned (Fig. 1).

JoyAge services involves collaboration between aged care and mental health care units, evidence-based psychosocial interventions delivered by trained social workers, peer support, and stepped care according to depressive symptom level (Supplementary Fig. 1 & Supplementary Table 1). For older people with depression risk factors only, selective prevention involves engagement activities delivered in community aged care units. Those with mild symptoms are provided with indicated prevention involving group-based psychoeducation and/or group-based psychotherapy (cognitive behavioral therapy or problem-solving therapy), depending on pre-defined presentation criteria and response, by community aged care units. Participants with moderate or more severe depressive symptoms are provided with individual psychotherapy and referral as needed, delivered by trained social workers from community mental health units, who completed a 256-h structured training program on the theory and practice of geriatric mental health, assessment, and evidence-based psychotherapies (CBT and PST) adapted for older adults.

Service receipt lasted for between 2 and 12 months, depending on

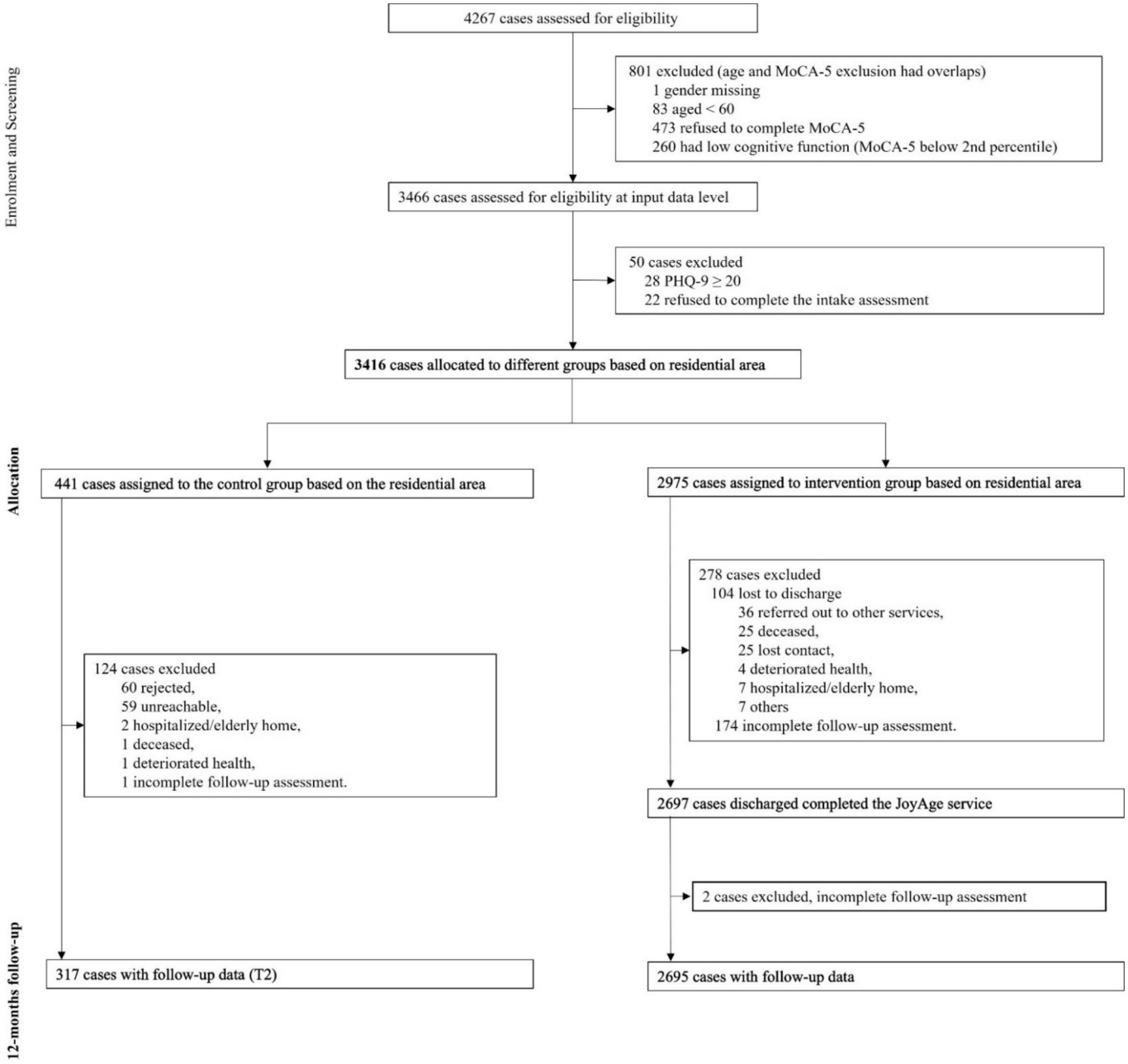

Fig. 1. CONSORT flow chart.

the entry symptom level and steps. The full service period included two phases: 1) initial engagement and active intervention, 2) a recovery period with ongoing monitoring and support from peer supporters through regular visits and calls, and a final exit planning session.

Social workers, upon completion of the training program mentioned earlier, assessed individuals after completion of services, and those who showed no response to JoyAge services (based on standardised assessment scores) after 12 months, severe depression, or imminent suicidal risks were referred to specialist mental health services. Peer supporters with a history of mental illness or risks for depression and who had recovered were recruited through partner NGOs and received peer supporter training (a 100-h structured training course plus on-site supervision). They helped recruit participants through outreach activities, assisted in therapeutic groups, and conducted regular follow-up visits with participants. Peer supporter was involved in view of their potential to engage older people in Chinese societies, where the stigma surrounding mental health issues is high (Tang et al., 2022). Peer support is a key feature of the JoyAge model, designed to provide continuous support and prevent relapse, particularly after the formal sessions. The detailed intervention protocol, social worker and peer supporter training have been described elsewhere (Liu et al., 2022).

Participants assigned to control received care as usual (CAU), which included health education, social and recreational activities, and other instrumental support in community aged care units, and individual counselling, clinical psychological services, and psychiatric referral mental health care units. All CAU were delivered by social workers and involved limited or no collaboration between the two services (Cheng et al., 2013).

2.4. Outcome measures

The primary outcome was change in depressive symptoms, assessed

using the validated Chinese version of the PHQ-9 (range 0–27) (Chen et al., 2010), and analysed as the total score at the 12-month follow-up compared to the baseline between the intervention and control groups. We compared changes in the total PHQ-9 score, as well as categorical changes in severity level of depressive symptoms based on validated cut-offs; namely: PHQ-9 total score 0–4 (at risk); 5–9 (mild); 10–14 (moderate), 15–19 (moderately severe), and 20–27 (severe) (Kroenke et al., 2001). Secondary outcomes included changes in anxiety, assessed using the validated Chinese versions of the Generalised Anxiety Disorder 7-item scale (GAD-7) (Spitzer et al., 2006), and loneliness, measured using the UCLA Loneliness Scale (UCLA-3) (Hughes et al., 2004), and analysed as changes in symptoms (total score) at T2 compared to T0. The severity level of anxiety symptoms was calculated for supplementary analysis; validated cut-offs were used; namely: GAD-7 total score 0–4 (no anxiety), 5–9 (mild), 10–14 (moderate), and 15–21 (severe) (Spitzer et al., 2006). We also recorded factors hypothesised to moderate the effect of the intervention, including education (whether any formal education received, coded as none vs yes, and years of formal education if yes), marital status (married/cohabiting vs others), living arrangements (living alone vs living with someone), socioeconomic status (recipient of means-tested welfare benefit vs non-recipient), mobility (able to move independently vs able to move with self-help tools vs relying on others/in-bed), hearing (left and right ear separately, normal hearing vs hearing problems), vision (normal vision vs some difficulty vs no vision), and cognition assessed using Hong Kong Montreal Cognitive Assessment 5-Minute Protocol (Wong et al., 2015).

Data were collected for both groups at baseline (T0) and 12-month follow-up (T2). JoyAge participants who were discharged (i.e., assessed by trained social workers, who showed improvements and were safe to exit the JoyAge service) within 10 months had an additional assessment time-point (T1). Social workers and researchers, after receiving the same assessment training, assessed JoyAge and control participants, respectively, and inputted the data in a password-protected web-based portal.

2.5. Statistical analysis

We followed the Transparent Reporting of Evaluations with Non-randomized Designs (TREND) statement in data analysis. We generated descriptive statistics of the demographic and clinical variables at the T0 assessment. The independent samples *t*-test was used to compare the means of continuous variables with normal distribution; the chi-square

Table 1
Characteristics of participants (ITT and PSM samples) at the baseline and group comparison.

	ITT				PSM			
	Overall (n = 3416)	CAU (n = 441)	JoyAge (n = 2975)	CAU vs. JoyAge	Overall (n = 844)	CAU (n = 422)	JoyAge (n = 422)	CAU vs. JoyAge
	N (%) / mean (SD)			p	N (%) / mean (SD)			p
Age, years	76.90 (8.20)	75.56 (8.56)	77.10 (8.12)	0.006	75.82 (8.41)	75.55 (8.54)	76.07 (8.28)	0.37
Sex, female	2686 (78.6)	335 (76.0)	2351 (79.0)	< 0.001	637 (75.5)	320 (75.8)	317 (75.1)	0.81
Education								
Years	5.07 (4.55)	5.82 (4.65)	4.96 (4.53)	0.50	5.80 (4.69)	5.79 (4.62)	5.82 (4.77)	0.92
No formal education	1114 (32.6)	98 (22.2)	1016 (34.2)	< 0.001	208 (24.6)	95 (22.5)	113 (26.8)	0.15
Missing	*36 (1.1)*	*5 (1.1)*	*31 (1.0)*		*0*	*0*	*0*	
Marital status				0.50				0.18
Married/cohabit	1377 (40.3)	171 (38.8)	1206 (40.5)		309 (36.6)	164 (38.9)	145 (34.4)	
Others	2006 (58.7)	266 (60.3)	1740 (58.5)		528 (62.6)	255 (60.4)	273 (64.7)	
Missing	*33 (1.0)*	*4 (0.9)*	*29 (1.0)*		*7 (0.8)*	*3 (0.7)*	*4 (0.9)*	
Economic status				0.32				0.33
Means-tested welfare benefit	1040 (30.4)	125 (28.3)	915 (30.8)		255 (30.2)	121 (28.7)	134 (31.8)	
Non-recipients	2376 (69.6)	316 (71.7)	2060 (69.2)		589 (69.8)	301 (71.3)	288 (68.2)	
Living status				0.001				0.34
Live alone	1423 (41.7)	215 (48.8)	1208 (40.6)		424 (50.2)	205 (48.6)	219 (51.9)	
Live with someone	1993 (58.3)	226 (51.2)	1767 (59.4)		420 (49.8)	217 (51.4)	203 (48.1)	
Mobility				0.002				0.003
Walk independently	2186 (64.0)	256 (58.0)	1930 (64.9)		540 (64.0)	250 (59.2)	290 (68.7)	
Move with self-help tools	1129 (33.1)	174 (39.5)	955 (32.1)		296 (35.1)	170 (40.3)	126 (29.9)	
Rely on others/in bed	48 (1.6)	2 (0.5)	46 (1.5)		8 (0.9)	2 (0.5)	6 (1.4)	
Missing	*53 (1.6)*	*9 (2.0)*	*44 (1.5)*		*0*	*0*	*0*	
Hearing				0.48				0.32
Left ear, normal hearing	2816 (82.4)	371 (84.1)	2445 (82.2)		701 (83.1)	357 (84.6)	344 (81.5)	
Missing	*34 (1.0)*	*2 (0.5)*	*32 (1.1)*		*0*	*0*	*0*	
Right ear, normal hearing	2825 (82.7)	381 (86.4)	2444 (82.2)	0.11	715 (84.7)	368 (87.2)	347 (82.2)	0.13
Missing	*39 (1.1)*	*1 (0.2)*	*38 (1.3)*		*0*	*0*	*0*	
Vision				0.025				0.68
Normal vision	2327 (68.1)	325 (73.7)	2002 (67.3)		613 (72.6)	312 (73.9)	301 (71.3)	
Some difficulty	1030 (30.2)	110 (24.9)	920 (30.9)		222 (26.4)	106 (25.1)	116 (27.5)	
No vision	22 (0.6)	4 (0.9)	18 (0.6)		9 (1.1)	4 (0.9)	5 (1.2)	
Missing	*37 (1.1)*	*2 (0.5)*	*35 (1.2)*		*0*	*0*	*0*	
PHQ-9 (0–27)	6.27 (3.76)	6.02 (4.81)	6.31 (3.58)	< 0.001	6.14 (4.17)	5.99 (4.83)	6.30 (3.39)	0.29
At-risk (PHQ-9 0–4)	1033 (30.2)	203 (46.0)	830 (27.9)		304 (36.0)	196 (46.4)	108 (25.6)	
Mild (PHQ-9 5–9)	1830 (53.6)	131 (29.7)	1699 (57.1)		379 (44.9)	125 (29.6)	254 (60.2)	
Moderate (PHQ-9 10–14)	452 (13.2)	80 (18.1)	372 (12.5)		124 (14.7)	74 (17.5)	50 (11.8)	
Moderately severe (PHQ-9 15–19)	101 (3.0)	27 (6.1)	74 (2.5)		37 (4.4)	27 (6.4)	10 (2.4)	
GAD-7 (0–21)	4.30 (4.34)	3.90 (4.35)	4.36 (4.45)	0.08	4.21 (4.33)	3.87 (4.30)	4.56 (4.35)	0.02
Missing	*136 (4.0)*	*2 (0.4)*	*134 (4.5)*		*27(3.20)*	*2 (0.5)*	*25 (5.92)*	
UCLA-3 (0–9)	3.90 (2.94)	3.36 (3.09)	3.98 (2.91)	0.001	3.56 (3.01)	3.36 (3.08)	3.76 (2.94)	0.06
Missing	*27 (0.8)*	*0 (0)*	*27 (0.9)*		*4 (0.47)*	*0*	*4 (0.95)*	

CAU, care-as-usual; GAD-7, General Anxiety Disorder-7 item; ITT, intention-to-treat; PHQ-9, The Patient Health Questionnaire – 9 items; PSM, Propensity score matching; SD, standard deviation; UCLA-3, UCLA Loneliness Scale – 3 items.

test was used to compare categorical variables, and Fisher's exact test was used for variables with low cell counts ($n < 5$) in the intervention (T0 vs T2; and T0 vs T1) and control groups (T0 vs T2). The independent samples Mann-Whitney *U* test was used for most ordinal clinical scales to examine whether the same distributions could be assumed across groups. As observations at two time-points were nested within individuals and individuals were nested within clusters (NGO centres), changes in outcome measures at 12-month follow-up (T2) from the baseline, including PHQ-9, GAD-7, and UCLA-3 scores, were assessed by multilevel linear mixed models to compare outcome changes between groups (JoyAge vs CAU), with adjusted mean differences (AMDs) between groups with 95% confidence intervals (CIs). In addition, we report standardised mean differences (SMDs) as effect size, calculated as the AMD of the outcome between the groups divided by the baseline SD of the outcome for both groups combined. Multiple imputations by chained equations (MICE) were performed to handle missing data (percentages summarised in Table 1). Fifty imputed data sets were obtained, and the results were pooled by Rubin's rule (Toutenburg and Rubin, 1990). Subgroup analyses were based on participants' depressive symptom severity (i.e., PHQ-9 total score cutoffs) at baseline. Effectiveness analyses were conducted using the intention-to-treat (ITT) principle with statistical software and packages (R version 4.1.1). To account for the unequal allocation of intervention groups, the same sets of analyses were conducted with a propensity score matched (PSM) sample as sensitivity analyses. Variables used in the propensity score model were demographic (age and gender) and socioeconomics (education, economic status and living status). The optimal matching method (1:1) was used. Two sets of supplementary analyses were conducted: 1) generalised linear regressions in ITT with changes in PHQ-9 total scores converted into clinically meaningful categories of 'response' (reduction in PHQ-9 scores ≥50%), 'remission' (follow-up PHQ-9 score < 5, i.e., asymptomatic) for those with baseline PHQ-9 score ≥ 5, and 'prevention' (follow-up PHQ-9 score < 5) for those who were asymptomatic at baseline (Nierenberg and DeCecco, 2001); and 2) multilevel linear mixed models with a per-protocol sample (i.e., attended ≥80% sessions within the service period, had a peer supporter in the recovery period, and completed the T2 assessment).

2.6. Role of the funding source

The funder had no role in the design, data collection, data analysis, and reporting of this study. The corresponding author had full access to all data in the study and had final responsibility for the decision to submit the manuscript for publication.

3. Results

3.1. Overview

We approached 4267 potentially eligible older people through community outreach events. Based on eligibility criteria, 801 individuals were excluded; 3466 were further assessed for eligibility at the input data level, and 50 were excluded. The remaining participants were assigned to intervention and control groups based on areas of residence (CAU, $n = 441$; JoyAge, $n = 2975$ in the ITT sample) (Fig. 1). In the JoyAge group, 2697 participants (90.7%) completed the services; the median service period was 9.93 months (IQR 6.87–13.10). The overall 12-month dropout rate (i.e., participants who did not complete the 12-month assessment) in the ITT sample was 11.8% (CAU: 28.1%; JoyAge: 9.4%); the JoyAge service had a better retention rate than CAU ($z = -11.35$, $p < .001$).

Table 1 shows the baseline demographics and clinical characteristics of the JoyAge and CAU groups in the ITT and PSM sample. In the ITT sample, participants had a mean age of 76.90 years (SD = 8.20), the majority were female (78.6%), and had a low level of education. CAU participants were younger, more educated, more likely to live alone, and more likely to move independently with or without tools. They also had better vision and scored lower on the PHQ-9 and UCLA-3 scales. These variables were included as a priori covariates in the linear mixed models. Supplementary Table 2 shows the descriptive clinical outcomes in the JoyAge and CAU groups at baseline, discharge, and 12-month follow-up in the ITT group. In the 1:1 PSM, 422 JoyAge cases were matched to 422 CAU cases. The PSM achieved a good balance between JoyAge and CAU, with all standardised mean differences below 0.1 after matching.

3.2. Twelve-month outcomes

At 12 months, all participants exhibited reduced depressive symptoms ($B = -1.52$, 95% CI -1.91 to −1.13, $p < .001$), anxiety ($B = -0.73$, 95% CI -1.16 to −0.30, $p < .001$), and loneliness ($B = -0.60$, 95% CI -0.89 to −0.31, $p < .001$). Among JoyAge participants, 51% responded (i.e., achieving a 50% reduction in PHQ-9 scores), compared with 38% in CAU. Among those with baseline PHQ-9 score ≥ 5, 71% of JoyAge participants and 45% of CAU participants achieved remission. In those with baseline PHQ-9 score < 5, 94% of JoyAge participants and 79% of CAU participants remained asymptomatic (Supplementary Table 2). In the ITT analyses, JoyAge showed significantly larger effects in reducing depressive symptoms (AMD = 1.65, 95% CI 1.24 to 2.07, $p < .001$; SMD = 0.44, 95% CI 0.33 to 0.55, $p < .001$), anxiety symptoms (AMD = 1.47, 95% CI 1.01 to 1.93, $p < .001$; SMD = 0.40, 95% CI 0.27 to 0.52, $p < .001$), and loneliness (AMD = 1.29, 95% CI 0.98 to 1.60, $p < .001$; SMD = 0.37, 95% CI 0.28 to 0.45, $p < .001$) than CAU (Table 2). In the PSM analyses, the results were similar, that JoyAge showed significantly larger effects in reducing depressive symptoms (AMD = 1.99, 95% CI 1.34 to 2.64, $p < .001$; SMD = 0.48, 95% CI 0.20 to 0.76, $p < .001$), anxiety symptoms (AMD = 1.62, 95% CI 0.95 to 2.29, $p < .001$; SMD = 0.37, 95% CI 0.08 to 0.67, $p < .001$), and loneliness (AMD = 1.03, 95% CI 0.58 to 1.48, $p < .001$; SMD = 0.34, 95% CI 0.14 to 0.55, $p < .001$) than CAU (Table 2).

3.3. Subgroup analyses

In ITT sample, subgroup analyses revealed that the effects of JoyAge were more prominent for those with moderate to moderately severe depressive symptoms at baseline (AMD = 2.49, 95% CI 1.51 to 3.47, $p < .001$; SMD = 0.71, 95% CI 0.43 to 0.99, $p < .001$) and those with risk factors only (AMD = 1.58, 95% CI 1.11 to 2.05, $p < .001$; SMD = 0.45, 95% CI 0.32 to 0.59, $p < .001$). JoyAge was also more effective than CAU for those with mild depressive symptoms at baseline, but the effect size was smaller than in the other two subgroups (AMD = 0.75, 95% CI 0.09 to 1.40, $p < .05$; SMD = 0.21, 95% CI 0.02 to 0.39, $p < .05$) (Table 3). In the PSM sample, the results were similar in those with moderate to moderately severe depressive symptoms at baseline (AMD = 3.73, 95% CI 2.55 to 4.91, $p < .001$; SMD = 1.46, 95% CI 1.07 to 1.86, $p < .001$) and those with risk factors only (AMD = 1.88, 95% CI 1.10 to 2.66, $p < .001$; SMD = 1.33, 95% CI 1.17 to 1.49, $p < .001$). However, for those with mild depressive symptoms at baseline, the two groups did not differ at 12 months (AMD = 0.83, 95% CI -0.03 to 1.69; SMD = 0.32, 95% CI -0.01 to 0.63).

3.4. Supplementary analysis

Supplementary Table 3 summarises the results from generalised linear models with response, remission, and prevention of depression of the ITT sample as alternatives to the primary outcome. The results are consistent with the main analysis, which shows that the JoyAge model was more effective than CAU in reducing depressive symptoms and preventing depression. Supplementary Table 4 shows the participant characteristics in the per-protocol sample ($n = 1962$). Supplementary Table 5 shows results from the multilevel linear mixed model analyses in the per-protocol sample, which were similar to those from the ITT

Table 2
Linear mixed models with key clinical outcomes from baseline to follow-up in ITT (n = 3416) and PSM (n = 844) samples.

ITT sample (n = 3416)	PHQ-9			GAD-7			UCLA-3		
	Coefficient	SE	95% CI	Coefficient	SE	95% CI	Coefficient	SE	95% CI
Age	−0.04***	0.007	[−0.06, −0.03]	−0.08***	0.01	[−0.09, −0.06]	−0.03	0.01	[−0.04, −0.02]
Sex, Female	0.15	0.13	[−0.1, 0.39]	0.46**	0.14	[0.18, 0.73]	0.11	0.10	[−0.08, 0.3]
Low income	0.35**	0.12	[0.11, 0.58]	0.29*	0.14	[0.02, 0.55]	0.42	0.09	[0.24, 0.6]
Living alone	−0.01	0.11	[−0.23, 0.21]	−0.19	0.13	[−0.44, 0.06]	0.90	0.09	[0.73, 1.07]
Mobility difficulty	0.55***	0.11	[0.34, 0.76]	0.25*	0.12	[0.01, 0.49]	0.29	0.08	[0.13, 0.46]
Hearing difficulty									
Left ear	−0.09	0.14	[−0.37, 0.19]	0.21	0.16	[−0.11, 0.53]	0.16	0.11	[−0.06, 0.37]
Right ear	0.25	0.14	[−0.03, 0.53]	0.09	0.16	[−0.22, 0.39]	−0.08	0.11	[−0.29, 0.13]
Vision difficulty	0.97***	0.11	[0.75, 1.19]	1.01***	0.13	[0.76, 1.25]	0.21	0.09	[0.04, 0.37]
Education, years	−0.02	0.01	[−0.04, 0.01]	−0.01	0.01	[−0.04, 0.02]	0.01	0.01	[−0.01, 0.02]
Intervention (ref: CAU)									
JoyAge	0.29	0.18	[−0.06, 0.64]	0.60***	0.20	[0.2, 0.99]	0.75***	0.14	[0.48, 1.01]
Time point (ref: baseline)									
Follow-up	−1.52***	0.20	[−1.91, −1.13]	−0.73**	0.22	[−1.16, −0.3]	−0.60	0.15	[−0.89, −0.31]
Intervention × Time point	−1.65***	0.21	[−2.07, −1.24]	−1.47***	0.24	[−1.93, −1.01]	−1.29	0.16	[−1.6, −0.98]
Effect size[a]		**SE**	**95% CI**		**SE**	**95% CI**		**SE**	**95% CI**
AMD[b]	1.65***	0.21	[1.24, 2.07]	1.47***	0.24	[1.01, 1.93]	1.29***	0.16	[0.98, 1.60]
SMD[c]	0.44***	0.06	[0.33, 0.55]	0.40***	0.06	[0.27, 0.52]	0.37***	0.04	[0.28, 0.45]
PSM sample (n = 844)	**PHQ-9 coefficient**	**SE**	**95% CI**	**GAD-7 coefficient**	**SE**	**95% CI**	**UCLA-3 coefficient**	**SE**	**95% CI**
Age	−0.06**	0.02	[−0.09, −0.03]	−0.11***	0.02	[−0.15, −0.08]	−0.05***	0.01	[−0.08, −0.03]
Sex, female	0.29	0.28	[−0.27, 0.84]	0.55*	0.28	[0.01, 1.09]	0.14	0.20	[−0.25, 0.53]
Low income	0.50	0.29	[−0.07, 1.06]	0.14	0.28	[−0.41, 0.69]	0.36	0.20	[−0.03, 0.76]
Living alone	−0.25	0.26	[−0.76, 0.26]	0.02	0.25	[−0.47, 0.51]	1.12***	0.19	[0.75, 1.49]
Mobility difficulty	0.54*	0.26	[0.02, 1.05]	0.25	0.26	[−0.25, 0.74]	0.19	0.19	[−0.17, 0.56]
Hearing difficulty									
Left ear	0.20	0.31	[−0.41, 0.81]	0.68*	0.31	[0.08, 1.28]	0.17	0.22	[−0.26, 0.61]
Right ear	0.82*	0.32	[0.2, 1.44]	0.64*	0.31	[0.03, 1.24]	0.29	0.23	[−0.15, 0.73]
Vision difficulty	0.77**	0.27	[0.24, 1.31]	0.42	0.26	[−0.08, 0.93]	0.03	0.19	[−0.35, 0.4]
Education, years	−0.03	0.03	[−0.08, 0.03]	−0.05	0.03	[−0.1, 0.01]	−0.03	0.02	[−0.07, 0.01]
Intervention (ref: CAU)									
JoyAge	0.31	0.28	[−0.23, 0.85]	0.76**	0.28	[0.21, 1.3]	0.39*	0.19	[0.01, 0.76]
Time point (ref: baseline)									
Follow-up	−1.49***	0.23	[−1.95, −1.03]	−0.72***	0.24	[−1.19, −0.26]	−0.59***	0.16	[−0.9, −0.27]
Intervention × Time point	−1.99***	0.33	[−2.63, −1.35]	−1.62***	0.34	[−2.29, −0.95]	−1.03***	0.23	[−1.47, −0.59]
Effect size[a]		**SE**	**95% CI**		**SE**	**95% CI**		**SE**	**95% CI**
AMD[b]	1.99***	0.33	[1.34, 2.64]	1.62***	0.34	[0.95, 2.29]	1.03***	0.23	[0.58, 1.48]
SMD[c]	0.48***	0.14	[0.20, 0.76]	0.37***	0.15	[0.08, 0.67]	0.34***	0.10	[0.14, 0.55]

AMD, adjusted mean difference; CAU, care-as-usual; CI, confidence interval; GAD-7, General Anxiety Disorder-7 item; ITT, intention-to-treat; PHQ-9, The Patient Health Questionnaire – 9 items; SE, standard error; SMD, standardised mean difference; UCLA-3, UCLA Loneliness Scale – 3 items.

* $p < .05$.

** $p < .01$.

*** $p < .001$.

[a] Effect sizes were reverse coded.

[b] A positive score means a more significant effect of JoyAge.

[c] SMD = AMD/sqrt ((N_{joyage}-1)xSD_{joyage}_T0^2 + ($N_{control}$-1)x$SD_{control}$_T0^2)/(N_{joyage} + $N_{control}$)-2)).

sample. In the subgroup analyses in the per-protocol sample (Supplementary Table 6), however, JoyAge was not more effective than CAU in people with mild depressive symptoms at baseline.

3.5. Discharge outcome of JoyAge participants

At discharge, JoyAge participants showed a significant reduction in total scores of PHQ-9 ($t(2,696) = 56.56$, $p < .001$) and depressive symptom severity level (z = 37.00, $p < .001$), total scores of GAD-7 ($t(2364) = 28.19$, $p < .001$) and anxiety symptom severity level (z = 21.75, $p < .001$), and total scores of UCLA-3 ($t(2365) = 38.82$, $p < .001$). Their PHQ-9 scores decreased by 55.0%; 61.5% responded to the intervention (i.e., reduction in PHQ-9 scores ≥50%); among those who scored ≥5 at the baseline ($n = 2145$), 61.6% showed remission (PHQ-9 < 5); and 84.2% of those at risk at the baseline ($n = 830$) did not develop depressive symptoms. For secondary outcomes, anxiety symptoms decreased by 49.54% and loneliness by 48.99% from baseline.

4. Discussion

This study provided real-world evidence that integrated late-life depression prevention can be effectively implemented at scale to reduce depressive symptoms, anxiety symptoms, and loneliness, compared with traditional community-based mental health or aged care. Previous studies have suggested the effectiveness of stepped care in treating clinical depression (Rivero-Santana et al., 2021). Applying the stepped care principle in prevention, we integrated community aged care and mental health care, with peer support for selective and indicated prevention. In societies with established, but separate, community services for aged care and mental health care, JoyAge or similar approaches can be a solution for an integrated service, especially in rapidly ageing societies with limited mental health workforce capacity.

The significance of symptom reduction in non-clinical populations should be considered in the context of its scale and the role that mild symptoms have in prevention. An earlier study in a population-based cohort of older people showed a clear dose-response relationship between depressive symptoms and suicide mortality with up to 10 years of follow-up, with no threshold effect – that is, even in older people with

Table 3
Subgroup analyses with primary outcome from baseline to follow-up in ITT (n = 3416) and PSM (n = 844) samples.

ITT sample (n = 3416)	At-risk group (*n* = 1033) [PHQ-9 0–4]			Mild depressive symptoms (*n* = 1830) [PHQ-9 5–9]			Moderate to moderately severe depressive symptoms (*n* = 553) [PHQ-9 ≥ 10]		
	coefficient	SE	95% CI	coefficient	SE	95% CI	coefficient	SE	95% CI
Age	−0.02*	0.01	[−0.03, 0]	−0.01	0.01	[−0.02, 0]	−0.05*	0.02	[−0.08, −0.01]
Sex, Female	−0.03	0.12	[−0.27, 0.22]	0.10	0.11	[−0.12, 0.32]	−0.08	0.27	[−0.61, 0.44]
Low income	0.22	0.12	[−0.02, 0.46]	0.39***	0.10	[0.19, 0.6]	0.03	0.25	[−0.45, 0.52]
Living alone	0.14	0.12	[−0.09, 0.37]	−0.09	0.10	[−0.28, 0.1]	0.26	0.23	[−0.19, 0.72]
Mobility difficulty	0.25*	0.11	[0.03, 0.47]	0.22*	0.09	[0.04, 0.4]	0.57*	0.24	[0.11, 1.04]
Hearing difficulty									
Left ear	−0.10	0.14	[−0.38, 0.18]	−0.08	0.13	[−0.34, 0.17]	−0.15	0.26	[−0.66, 0.36]
Right ear	0.07	0.15	[−0.22, 0.35]	0.12	0.13	[−0.13, 0.37]	−0.06	0.26	[−0.56, 0.45]
Vision difficulty	0.23	0.12	[0, 0.47]	0.30***	0.10	[0.11, 0.49]	0.24	0.22	[−0.19, 0.67]
Education, years	−0.01	0.01	[−0.04, 0.01]	−0.03	0.01	[−0.05, −0.01]	−0.02	0.03	[−0.07, 0.03]
Intervention (ref: CAU)									
JoyAge	0.56**	0.16	[0.24, 0.87]	−0.35	0.22	[−0.78, 0.08]	−0.38	0.35	[−1.07, 0.31]
Time point (ref: baseline)									
Follow-up	0.96***	0.22	[0.53, 1.39]	−2.55***	0.33	[−3.19, −1.91]	−4.97***	0.46	[−5.86, −4.08]
Intervention × Time point	−1.58***	0.24	[−2.05, −1.11]	−0.75*	0.33	[−1.4, −0.09]	−2.49***	0.50	[−3.47, −1.51]
Effect size[a]		**SE**	**95% CI**		**SE**	**95% CI**		**SE**	**95% CI**
AMD[b]	1.58***	0.24	[1.11, 2.05]	0.75*	0.33	[0.09, 1.40]	2.49***	0.50	[1.51, 3.47]
SMD[c]	0.45***	0.07	[0.32, 0.59]	0.21*	0.09	[0.02, 0.39]	0.71***	0.14	[0.43, 0.99]
PSM sample (n = 844)	**At-risk group [PHQ-9 0–4] (*n* = 304)**			**Mild depressive symptoms [PHQ-9 5–9] (*n* = 379)**			**Moderate to moderately severe depressive symptoms [PHQ-9 ≥ 10] (*n* = 161)**		
	coefficient	**SE**	**95% CI**	**coefficient**	**SE**	**95% CI**	**coefficient**	**SE**	**95% CI**
Age	−0.002	0.02	[−0.03, 0.03]	−0.01	0.02	[−0.04, 0.03]	−0.06	0.04	[−0.13, 0.02]
Sex, Female	0.06	0.26	[−0.45, 0.56]	−0.12	0.28	[−0.66, 0.43]	−0.43	0.58	[−1.56, 0.71]
Low income	−0.01	0.28	[−0.55, 0.54]	0.49	0.27	[−0.04, 1.02]	0.21	0.52	[−0.81, 1.22]
Living alone	0.03	0.25	[−0.46, 0.53]	0.00	0.24	[−0.47, 0.48]	−0.69	0.51	[−1.68, 0.31]
Mobility difficulty	0.05	0.26	[−0.46, 0.57]	0.03	0.24	[−0.45, 0.51]	0.74	0.57	[−0.39, 1.86]
Hearing difficulty									
Left ear	0.13	0.31	[−0.48, 0.74]	−0.01	0.30	[−0.6, 0.58]	−0.27	0.56	[−1.36, 0.82]
Right ear	0.06	0.32	[−0.56, 0.69]	0.67	0.32	[0.04, 1.3]	0.38	0.54	[−0.69, 1.45]
Vision difficulty	0.11	0.29	[−0.46, 0.69]	0.18	0.26	[−0.33, 0.69]	0.28	0.50	[−0.69, 1.25]
Education, years	0.00	0.03	[−0.06, 0.05]	−0.05	0.03	[−0.11, 0.01]	−0.03	0.05	[−0.13, 0.07]
Intervention (ref: CAU)									
JoyAge	0.64	0.29	[0.07, 1.21]	−0.46	0.30	[−1.04, 0.12]	−0.67	0.60	[−1.85, 0.5]
Time point (ref: baseline)									
Follow-up	0.86**	0.27	[0.34, 1.38]	−2.50***	0.36	[−3.21, −1.79]	−4.79***	0.51	[−5.78, −3.8]
Intervention × Time point	−1.88***	0.40	[−2.67, −1.09]	−0.83	0.44	[−1.7, 0.04]	−3.73***	0.83	[−5.36, −2.09]
Effect size[a]		**SE**	**95% CI**		**SE**	**95% CI**		**SE**	**95% CI**
AMD[b]	1.88***	0.40	[1.1, 2.66]	0.83	0.44	[−0.03, 1.69]	3.73***	0.60	[2.55, 4.91]
SMD[c]	1.33***	0.08	[1.17, 1.49]	0.32	0.16	[−0.01, 0.63]	1.46***	0.20	[1.07, 1.86]

AMD, adjusted mean difference; CAU, care-as-usual; CI, confidence interval; GAD-7, General Anxiety Disorder-7 item; ITT, intention-to-treat; PHQ-9, The Patient Health Questionnaire – 9 items; SE, standard error; SMD, standardised mean difference; UCLA-3, UCLA Loneliness Scale – 3 items.

* $p < .05$.

** $p < .01$.

*** $p < .001$.

[a] Effect sizes were reverse coded.

[b] A positive score means a more significant effect of JoyAge.

[c] SMD = AMD/sqrt ((N$_{joyage}$-1)xSD$_{joyage}$_T0^2 + (N$_{control}$-1)xSD$_{control}$_T0^2)/(N$_{joyage}$ + N$_{control}$)-2)).

subthreshold symptoms, any symptoms in otherwise healthy older people predicted suicide mortality risks (Sun et al., 2012). PHQ-9 has been shown to be useful in assessing intervention outcome, especially when the standard definition of clinically significant improvement (50% symptom reduction) is supplemented with remission status (asymptomatic and a lower PHQ-9 score) (McMillan et al., 2010). The small but significant improvement in symptoms with this new service, compared with traditional community services, can have potentially significant impacts for individuals and society. The pragmatic trial design means that no further 'translation' is needed for service implementation to achieve real-world impacts. Longer-term follow-up and economic analyses would further inform service implementation.

The effects of JoyAge differed across prevention levels. For those with moderate to moderately severe depressive symptoms, there was a medium to large effect in reducing depressive symptoms. This finding is similar to those observed in stepped care in other populations (Rivero-Santana et al., 2021), as people with subsyndromal disorders may benefit from a stepped-care approach due to their higher risk of developing a major depressive disorder (Schoevers et al., 2006). In addition, the individual psychotherapy that proved highly effective for the moderate-to-moderately-severe group was delivered by social workers, who were specifically trained to supplement the existing, highly stretched mental health specialist workforce in Hong Kong. This finding provides support for a task-sharing model, demonstrating that with specialized training and structured supervision, the existing social care workforce can be empowered to deliver effective evidence-based psychological interventions. This provides a scalable solution to the significant shortage of professional geriatric mental health specialists in Hong Kong and other similar settings.

JoyAge service was also effective for older people with depressive risk factors, with a medium effect. Existing aged care services in Hong Kong were unprepared to deliver mental health care services without relevant training and service model (Liu et al., 2022). With proper training about mental health, aged care unit service providers can deliver low-intensity interventions to prevent these at-risk older people from developing late-life depression. Trained peer supporters offered

meaningful companionship, which is also lacking in existing services for older people with risk factors for depression (Tang et al., 2022), such as loneliness and social isolation.

The effect of JoyAge for those with mild depressive symptoms at service entry is less robust. This could be attributed to the characteristics of routine community care in Hong Kong. Community aged care in Hong Kong provides engagement activities, with some similarities to the behavioral activation approach in JoyAge for those with mild depressive symptoms (Scazufca et al., 2022).

4.1. Limitations

There are several study limitations. First, due to feasibility considerations, we used a non-randomised design and allocated participants based on their residential district. To address potential bias, we recruited a large sample and controlled for a range of potential confounders. Despite a large sample, the sizes of the two groups were uneven. The use of the propensity score method to select matching samples may have addressed this issue, although a randomised controlled trial would provide more robust evidence. Second, this study recruited a community sample with no formal depression diagnosis, nor did we track whether the clients referred out had a clinical diagnosis. Therefore, although significant reduction and a low level of depressive symptoms may be protective against onset, we did not provide definitive evidence of JoyAge's effects on the prevention of major depression. Third, CAU and JoyAge participants were assessed by different assessors. We attempted to minimise assessor bias by providing standardised training and manual as a solution in a pragmatic trial. Finally, we do not have sufficient information to identify the potential 'active ingredient(s)' in the JoyAge program, including the increased social contact and attention participants received from program staff and peer supporters. This should be explored in future research, for example through the inclusion of an attention control group and/or process evaluation design, to allow identification of therapeutic components to ensure effective implementation and scaling up.

5. Conclusions

With population ageing, even in high-resource settings, the unavailability of evidence-based psychotherapies for late-life depression is a call for clinical and public policy changes (Walaszek, 2024). The integrated prevention programme JoyAge reduced depressive symptoms, anxiety, and loneliness in older people with risk factors for depression or subsyndromal depressive symptoms, compared with traditional community mental health or aged care. These results are pertinent to improving mental health for older people in the community, especially in rapidly ageing societies and low-human-resource settings. Longer-term follow-up and economic analyses are needed to further inform implementation.

CRediT authorship contribution statement

Tianyin Liu: Writing – review & editing, Writing – original draft, Validation, Supervision, Project administration, Methodology, Formal analysis. **Dara Kiu Yi Leung:** Writing – original draft, Validation, Formal analysis, Data curation. **Daniel Wong:** Conceptualization. **Samson Tse:** Conceptualization. **Paul Wong:** Conceptualization. **Siu Man Ng:** Conceptualization. **Wai Chi Chan:** Conceptualization. **Vivian Lou:** Conceptualization. **Jennifer Yee-Man Tang:** Conceptualization. **Reynold Cheng:** Conceptualization. **Shiyu Lu:** Writing – review & editing, Formal analysis. **Frankie Ho Chun Wong:** Data curation. **Wen Zhang:** Validation, Formal analysis. **Lesley Cai Yin Sze:** Data curation. **Wai Wai Kwok:** Supervision, Project administration. **Martin Knapp:** Writing – review & editing, Conceptualization. **Terry Yat Sang Lum:** Supervision, Funding acquisition, Conceptualization. **Gloria Wong:** Writing – review & editing, Writing – original draft, Validation, Supervision, Funding acquisition, Conceptualization.

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Declaration of competing interest

The authors have no conflicts of interest to disclose.

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Appendix A. Supplementary data

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